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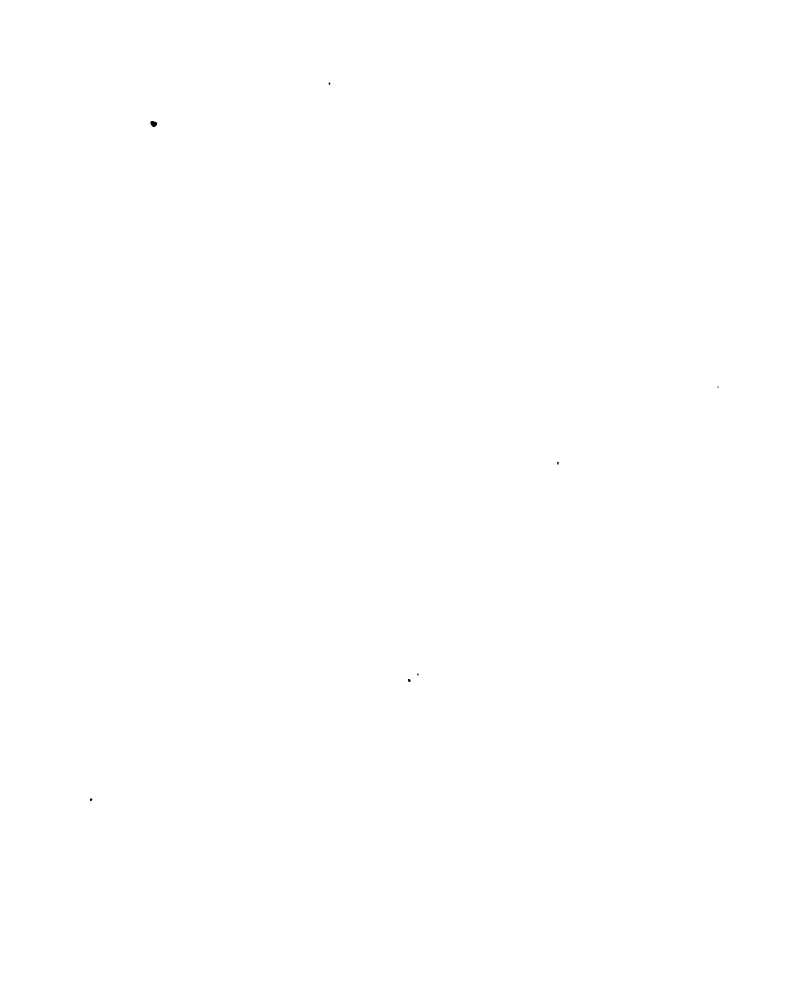
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INFANTRY FIRE;

ITS USE IN BATTLE.

By ^{Capt.} JOS. B. BATCHELOR, Jr.,

First Lieutenant, 24th U. S. Infantry.

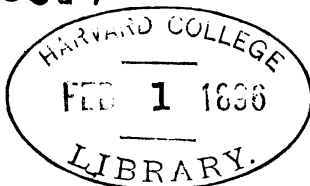
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THIS BOOK IS RESPECTFULLY DEDICATED TO

MAJOR ARTHUR MacARTHUR,

ASSISTANT ADJUTANT GENERAL, UNITED STATES ARMY,

IN GRATITUDE FOR HIS EFFORTS IN BEHALF OF A

HIGHER STANDARD AND BETTER MEANS

OF MILITARY EDUCATION.

10. *Chrysomelidae* (see also 11. *Chrysomelidae*)

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PREFACE.

THE merit of this book lies in the importance of its subject. This has been extensively studied in Europe, but hardly at all here, and yet there is no branch of his profession which more demands the attention of the military student, since none more affects the value of our forces and the fate of our arms.

The writer is fain to admit, before plagiarism is imputed, that his matter is largely drawn from the thoughts and writings of others, especially from those of Major Mayne of the British Army. This author has collected from many sources a mass of information covering the whole subject, but his work is not, in form and style, adapted to the use of our Army; a want which the present volume is intended to supply.

This work does not aspire to exhaust the subject, but to present it in a clear and concise form to the military men of the United States, until a better comes to take its place.

It is believed that this book is better illustrated than any on the subject which has preceded it; an advantage due to the

skill and care of Lieut. E. S. Wright, Ninth Cavalry, by whom the drawings were made.

The writer's thanks are due and gladly paid, to Colonel E. F. Townsend, Twelfth Infantry, and Major Arthur MacArthur, Assistant Adjutant General, by whose support the work was made possible.

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EPITOME.

The bullet is subject to many causes of deviation.

The effects of these are known or discovered on the target range, but unknown in battle.

The bullets cannot all follow the mean trajectory.

We must then find some determinable dispersion on which to make a calculation of the value of individual fire in battle.

The only determinable dispersion is that due to the rifle and ammunition, which is less than that which will actually occur.

The value of individual fire, thus determined, gives a limit beyond which this fire becomes unprofitable in battle.

This limit depends on the qualities of the rifle and on the dimensions of the object, and can be found for any weapon and object.

Beyond this limit individual fire is replaced by collective fire.

The dispersion of collective fire, when the firers are trained, is nearly constant.

There is a limit of profitable collective fire, dependent on this dispersion and on knowledge of the range.

Collective fire is made possible only by Fire Discipline.

For this reason infantry should be trained to act in groups or "Fire Units," under recognized leaders.

The inclination of the ground affects the efficacy of fire.

Hence officers should learn the nature and extent of this influence, in order that they may suitably direct and control fire of their men.

Ammunition is precious in war, because it is difficult to place.

The best possible method should be adopted for its replacement.

There is an intimate connection between the use of infantry fire and all branches of tactics.

INTRODUCTION.

Success in war depends on success in battle. All the computations of strategy would be vain if a commander were not able to reap their fruits in victory in the resulting combat; hence the instruction of the soldier should aim at giving him the qualities by which battles are won.

Secret of Success.—The secret of success lies in superiority of fire, and this can be gained only by careful training of the individual soldier in the use of his rifle, and in that discipline which alone can enable fire to be properly directed and the expenditure of ammunition controlled. The absence of training, its improper direction, will prepare the way for a waste of cartridges, resulting only in exhaustion of ammunition, and consequent defeat.

Open Order.—The general adoption of some deployed formation renders the control of the firer especially difficult just when the increasing rapidity of fire renders it especially important. Instruction in individual firing at known ranges will not suffice. The importance given to this individual fire in our day will find no application in war, where many circumstances combining will deprive it of all value, except at short ranges. The education of the soldier must prepare him for controlled firing.

A Mistaken Principle.—We have for some years acted the principle that any soldier having good eyesight could make a good shot; that his failure to become one must be to lack of zeal on the part of his officers; and that individual instruction was all he needed. There is no doubt of the value of individual training, but there are some men who cannot be made good shots, even on the target range; and even if we succeeded in perfecting every soldier in this particular branch of fire, and stopped there, our training would induce an exaggerated faith in individual fire and lead to waste of ammunition in battle. The fact is that very few men are individually good shots when under fire, and these few have their skill nullified in the field by the excitement of battle and by ignorance of the range.

The simple experiment of firing at the 600 yards range and the 700 yards sight will show the importance of the latter.

Fire in War.—Uncontrolled fire is suitable only for small ranges. Fire in war must be the collective, controlled fire of masses, up to the time when the shortening of the distance between the opposing forces, the resulting excitement, and the noise of arms make control no longer possible. Even with the best training this time will come soon enough—it should be postponed to the last possible moment—and this can only be done by training the men to do in peace what they will do in war.

German Method.—The Germans, since 1877, have made important modifications in the conduct of fire on the field.

battle, substituting the regulated, sudden, and intermittent fire of masses for the old continuous and interminable fire of infantry. While still upholding the importance of having good marksmen in collective firing, they especially bring out the fact that good results can be obtained with average men, under the condition that these men are kept in hand by a particular fire discipline.

In the following pages the attempt will be made to show the true scope of musketry instruction, and for that purpose to establish the following propositions:

That variations in the rifle, the firer, and the external conditions, cause a dispersion of shots, which may be decreased but not removed, and that therefore uncontrolled fire beyond certain short ranges is not only useless but harmful.

That the collective, controlled fire of masses is useful at much longer ranges, and therefore essential to the proper use of the rifle.

That, in order properly to direct the fire of their men, officers must study the influence of ground on the effects of fire.

That the supply of ammunition in battle must be carefully provided for, and economy of ammunition rigidly enforced.

That the means for restricting uncontrolled fire to its proper place, for giving to collective fire its proper efficacy, and for economizing ammunition, must be found in "Fire Discipline," founded on the proper training of the Fire Units,

CHAPTER 1.—THE TRAJECTORY.

The power to make the best use of the rifle depends on a knowledge of its properties, which we will therefore first consider.

Effect of Projectile Force.—The projectile force impressed upon the bullet by the explosion of the powder acts as long as the bullet remains in the barrel, causing it to move with increasing velocity until it leaves the muzzle. The velocity of the bullet at this instant is called the "initial velocity," and is measured by the number of feet it would move in a second of time if the velocity remained unaltered during that second.

If the bullet after leaving the muzzle were subjected to no other forces, it would continue to move with unchanged velocity in the prolongation of the axis of the bore, passing over equal spaces in equal times.

Resistance of Air.—The air, displaced by the bullet, offers a resistance which reduces the velocity of the bullet, causing the spaces over which it passes in equal times continually to diminish.

Thus, if, neglecting the resistance of the air, a bullet would reach at the end of one second a point A, this resistance would cause it to reach only some point A', and at the end of two, three and four seconds, only to reach points as B', C', and D', instead of B, C, and D.

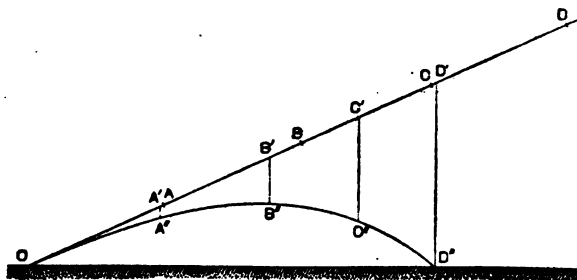


FIG. 1.

Remaining Velocity.—The diminished velocity at any point is called the remaining velocity at that point, and is measured by the space which the bullet would pass over in the next second if the velocity suffered no change.

Gravity.—On leaving the muzzle the bullet is subjected to the force of gravity, which causes it to fall about 16 feet in the first second, 48 feet in the 2d, or 64 in two seconds, 80 in the 3d, or 144 in three seconds, &c.; the fall in any second being about 32 feet more than in the next preceding.

The fall due to gravity is not influenced by the velocity of the bullet, being the same as if the bullet were dropped from a state of rest.

Thus our bullet instead of being at A' will be at the end of one second at A'', 16 feet below A'. At the end of two sec-

onds it will be at B'', at the end of three seconds at O'',. The resistance of the air reduces the velocity of the bullet's fall but this effect is not important at moderate ranges.

The curved path followed by the bullet under the combined action of these forces is its "trajectory."

Definitions.—The "time of flight" for any point, is the time required for the bullet to go from the origin of fire to that point. On it depends the curvature of the trajectory, for the longer the time of flight the greater the fall.

The "ordinate" of any point is its vertical distance above the line of sight.

The "greatest height" of the trajectory is the greatest height reached by the bullet in its flight for that range. It is reached in one-half the time of flight; hence, since the velocity continually decreases, it is more than one-half the range distant from the origin of fire.

The "flatness of the trajectory" is measured by the ratio between the range and greatest height.

The "first catch" is the first point at which the descent of the bullet has brought it within the height of the object.

The "first graze" is the first point at which the bullet, if unobstructed, would meet the ground.

The "dangerous zone" is the space in which the object may be struck. It extends from first catch to first graze.

The "angle of fall" is that between the ground and the tangent to the trajectory where it meets the ground. As it increases, the dangerous zone decreases.

Properties of the Rifle.—The five qualities of the rifle, in order of their relative importance, are :

1. Long range.
2. Flatness of trajectory.
3. Accuracy.*
4. Rapidity of fire.
5. Penetration.

All rifles now used possess the first and fifth qualities in a sufficient degree, so that they need not be considered further.

Advantages of Flat Trajectory.—As the trajectory grows flatter, the ordinates and the angle of fall decrease, the ground is better covered, and there is greater probability of hitting an object of given height.

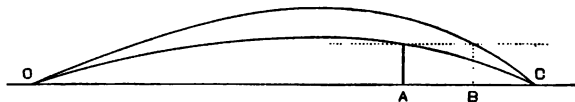


FIG. 2.

Hence, we may consider the second as really the most important quality of a military rifle. It is especially important at the shorter ranges, where we can hardly expect men in battle to do more than to hold the rifle parallel to the ground. It is an advantage independent of the firers, and the principal

*Defined on page 32.

aim in improving the rifle should be an increase in flatness of trajectory.

Increase of accuracy can be utilized only by good shots. It is for this reason placed third on the list—not because it is unimportant, but because, unlike flatness of trajectory, it is an advantage only for the few good shots, and not for the whole body of firers.

CHAPTER 2.—VARIATIONS IN THE TRAJECTORY.

Definitions.—Individual fire* is that in which the object, elevation and consumption of ammunition are in the discretion of the firer.

Collective fire is that in which object, elevation and consumption of ammunition are directed by the leaders. The firing may or may not be simultaneous, but it is regulated.

The former is uncontrolled and the latter controlled fire.

Spread of the Bullets.—If the rifle be aimed for a number of shots exactly at the same point, with the same elevation, the bullets will not strike the same point, but will be spread over a considerable surface, whose dimensions increase with the range. This is called the “shot-group.”

Causes.—The causes which lead to this scattering of the shots may be divided into three classes :

1. Those due to the rifle and ammunition.
2. Those due to the firer.
3. Those due to external conditions.

They may be also considered as regular and irregular causes of error. The former (due to rifle and ammunition) will pro-

* Sometimes called “independent fire.” The term is rejected, because the action of the firer should never be really *independent*.

duce a nearly constant dispersion, and leave the firer still able by suitable corrections, to group his hits near the point of aim. The latter (due to firer and external conditions) cause a bad grouping of the hits, and render it more difficult to place, not only each shot, but the whole group.

Imperfections in Rifle and Ammunition.

VARIATIONS IN RIFLES.

Rifles are not and cannot be identical; slight differences will occur, which, affecting the initial velocity, cause variations in the trajectories of rifles of the same pattern. Each weapon has its peculiarities, which the owner should find out and allow for.

The object sought is uniformity of manufacture, so that rifles of the same pattern shall be as nearly alike as possible. Certain small differences must be permitted for the sake of facility and cheapness of manufacture, but these should be made as small as possible, for considerable variations would shake the confidence of the soldier in his weapon.

Rear Sight.—The graduations of the rear sight are determined by a great number of experiments; but, when thus determined, the sights are engraved to pattern. Thus each sight cannot be perfectly graduated for the particular rifle on which it is placed.

In fixing the sights on a number of rifles, slight errors will arise in placing them. If the rear sight be to the right, the shots will go to the right; if the fore-sight be to the right, the

will go to the left. If the sights be bent to one side, the effect is the same as if they were improperly placed. If the rear sight is bent backward or forward, the graduations will be too low for the range; if the fore-sight is bent, they will be too high.

Drift.—The rotation given to the bullet by the rifling causes a horizontal deviation called the drift, which increases more rapidly than the range. This deviation is very nearly corrected by the Buffington rear sight.

Jump.—The “jump” of the rifle is independent of the soldier, but can be made more regular by taking care always to hold the piece in the same way to the shoulder. It is not constant, however, but varies with the position of the firer, the manner of holding, the initial velocity, and the angle of elevation.

Distribution of Metal.—Rifles experience while being fired, independently of the jump and the firer, deviations in both horizontal and vertical directions, which cause the muzzle to describe a sort of elliptical spiral, with the greater axis vertical. It is due to a want of symmetry in the distribution of the metal of the barrel. This want of symmetry also causes a deviation immediately due to unequal heating, and to irregularity in the wave of metal caused by the passage of the bullet through the bore. Permanent projections on the barrel have the same effect. If the bands be too tight, the wave of metal is checked, and with it the passage of the bullet.

Fouling.—After each shot, the powder leaves in the barrel a variable quantity (about .6 of the original charge) of a solid,

moist, black residue, called the fouling. The collection of it in the grooves seriously affects the fire; hence, they should be as shallow as possible. The smaller the calibre, the greater the chance of this evil, since the same amount of fouling is then spread over a smaller surface.

As the barrel gets hotter, the fouling dries and cakes, and impedes the passage of the bullet.

Temperature of Barrel.—The temperature of the barrel also affects the shooting more directly. As the barrel expands with heat, the size of the bore and the sectional area of the bullet also increase, and the latter increases the retardation due to resistance of the air.

Rust, etc.—If the bore be rusted, the resistance to the passage of the bullet will be increased, its proper expansion prevented, its rotation impaired, and its initial velocity diminished. Irregularity of fire is also produced by damage to the muzzle by scratching or leading of the bore, by enlargement of the bore due to bad cleaning, and by any dents in the barrel.

From all these it results that not even two consecutive shots can be fired under precisely the same conditions, and that even if no other source of error exists, a number of shots fired from a rifle held in a vise will not all strike the same point, but will spread over a considerable surface.

DUE TO AMMUNITION.

For ammunition, as for the rifle, uniformity of manufacture is aimed at, but practically unattainable. Certain small variations

tions must be allowed both in the bullet and in the powder, which cause differences in the initial velocity independent of other considerations.

Bullet.—Any change in the bullet — its weight, diameter, or form — affects the retardation

Powder.—Powder is a mechanical mixture of 75 per cent. of saltpetre, 10 per cent. of sulphur, and 15 per cent. of charcoal; but however careful the manufacture, these proportions will vary slightly. The density and size of the grain and the amount of moisture will also vary.

In the operation of loading, slight differences occur in the weight of the powder charge. The differences of initial velocity due to these variations in the weight and character of the powder are very considerable. No two cartridges give exactly the same results, “a difference of 50 f. s. being sometimes found in cartridges from the same packet.”

Case.—Changes in the exterior diameter of the cartridge-case affect the closeness with which it is supported by the walls of the chamber, the amount of force lost in expanding it, and hence the initial velocity. Changes in the interior dimensions of the case also affect it.

Imperfections in the Firer.

These are probably the chief source of errors in the firing. Every variation in the manner in which the rifle is held, and in which the trigger is pulled, every change in the amount of

fore-sight taken, every lack of clear definition in the sight causes the shot to be differently placed.

Clear Sight.—Clear definition of the object is essential to good shooting. This is affected not only by the firer's eyesight but by many other causes, such as the color of the object and of the background, the distance, the state of the light, etc.

Fore-sight and Object.—At long ranges the fore-sight will cover a great part even of a large object, so that the firer does not know whether he is aiming too high or too low, to the right or to the left, and certainly not whether he is aiming at the center of the object. Thus at long ranges large objects, such as bodies of troops in close order, form the only suitable objectives; but troops are not likely to expose themselves to fire in such formations.

Inclining Sights.—Any inclination of the rear sight causes the shot to go low and on the side of the inclination. This is a very common error, even on the target range, and will become much more common in the excitement of action. At 800 yards a slight inclination would cause a 6x8 target to be missed entirely.

Adjusting.—The rear sight must be accurately adjusted to the proper elevation. An adjustment with the finger alone can hardly be made within $\frac{1}{16}$ inch. This at 500 yards would make a difference of 2.5 feet in the height of the hit on a vertical target. At 1,000 yards it will make a difference of 6 feet. This error of $\frac{1}{16}$ will probably be greatly exceeded by men under fire.

Position and Condition.—The position of the eye with reference to the rear sight affects the amount of fore-sight taken. A line of sight, taken with the eye 2 or 3 inches from the rear sight, may appear off the target, if the head could be drawn back without moving the rifle.

As the range increases so does the elevation to be used, which causes the firer's position to be strained, inducing unconscious changes in it, and makes it more difficult for him to judge whether the rear sight is vertical. The eyesight and steadiness of the firer are affected by his general condition, by fatigue, and by what he has been eating and drinking. This is a great source of variation in his shooting.

Varying Fore-sight.—Variations in the amount of fore-sight taken are of constant occurrence.* All men should be taught to use a full sight. The fine sight is all very well for the target range or the competition, but these are not the places where we must train the soldier to play his part. In action the men will be weary with marching and breathless with running, the targets will be seen indistinctly and only for a short time, and aim, if taken at all, will be so hurried that a full sight will always be used; and the men should be taught in the individual training, which is merely the preliminary for battle, to know where his shot will go when he uses that sight.

*A difference of 10' of arc, caused by this variable amount of fore-sight, makes a difference in the position of the line of sight of .873 foot for each 100 yards in the range.

Our Firing Regulations prescribe shades of difference in amount of fore-sight to be used, which are pretty, but entirely impracticable under fire. It is useless to train men to do what they will not do and cannot do in war.

Pulling.—The trigger, which ought to be pressed back without deranging in any way the position of the rifle, is almost always *pulled*, even on the target range, giving the shots a continual and *variable* tendency towards the right.*

Flinching.—The soldier often flinches as he fires. This is especially apt to be the case if the recoil is heavy, and after a few rounds have been fired. The recoil often injures the finger by causing the trigger-guard to strike it. When we consider how many rounds a man may be called on to fire in modern battle, these become serious considerations. The objects at which men fire in action will often be moving, which greatly decreases the chance of hitting.

All these causes, conspiring with others, make the shooting of men, even when well trained on the range, a very different thing when opposed to other men firing at them. When, hungry, thirsty, weary, with smoke drifting into his eyes, he hears the sounds and sees the sights of battle, the errors of the fire will enormously increase, and he will have no one to signal him their direction or extent.

*For this reason, the French give a left-handed twist to the rifling, in order that the pull and drift may tend to counteract each other.

External Conditions.

There are many things independent both of rifle and firer which cause variations in the trajectory.

Knowledge of Range.—For effective individual shooting, the range must be known. This condition can be rarely fulfilled.*

It can be approximated by various means, and every effort must be made to determine it as accurately as possible. If any artillery are near at hand the range can be ascertained from them, since they have means of finding it.

The use of range-finders, of which several are described in a later chapter, should be familiar to officers and non-commissioned officers of infantry.

Failing these means, the range must be determined by the eye, and the best men in each company should be carefully trained in this estimation. The capacity of different men for this instruction is widely different, and it would be wiser to train the best thoroughly than to take time to train all poorly.

Atmospheric Variations.—The rear sight of a rifle is graduated for a standard temperature, barometric pressure, state of air and force of gravity. All these are subject at short intervals to *unknown* variations, causing corresponding errors in the firing.

*We have already seen that even when known, the elevations engraved on the rear sight furnish an approximate guide.

Temperature.—If the temperature increases, the density of the air decreases, the retardation also decreases, and the range and height of the hit increase. If the temperature decreases, the reverse will be the case.

Barometer.—If the barometer rises, the air is denser, retardation greater, and the range less. If it falls, the reverse obtains.

Aqueous Vapors.—If the air is full of aqueous vapor, the elastic force of this decreases the density and resistance of the air. Fine dry days may require as much as $\frac{1}{8}$ inch more elevation than damp days, for this reason.

Rain, etc.—Rain and snow increase the density of the air and decrease the range. The fouling dries rapidly on hot days, and, caking in the bore, reduces the velocity of the shot. On wet days it remains moist, and acts as a lubricant.

As the temperature increases the moisture of the air usually increases, decreasing the density and retardation.

Gravity.—The force of gravity decreases as the elevation above the sea increases, and in high countries the elevation must be decreased for a given range. Glare in the eyes, weakness of the air, smoke, fog, mists, cold, all interfere with shooting. Dust and smoke driven into the eyes form another source of error.

Clouds.—Clouds and bright sunshine have a considerable effect. On bright, hot days there are frequently local currents in the air, due to unequal heating of the ground, causing deflections for which the firer cannot account.

Light on Sights.—Alternate clouds and sunshine affect not only the atmospheric conditions, but the manner of aiming—the latter in a very variable way. As a rule, when the sun shines from the right it lightens the right edge of the fore-sight and the left side of the notch of the rear sight, causing aim to be taken by these and the shot to go to the left. If the sun shines from the left, the shot will usually go to the right.

A fuller sight will be taken on a dark day than on a bright one—another reason for always using a full sight.

Wind.—Wind affects the flight of the bullet according to its strength and direction. The effect of a wind directly in the plane of the trajectory is to retard or accelerate the bullet. A constant side wind causes it to deviate horizontally in a curve similar to the trajectory, the constant pressure of the wind replacing the constant force of gravity. A strong wind also increases the density of the air, and therefore the retardation of the bullet.

Attitude.—The shooting is affected not only by the attitude of the firer, but by slight changes of position, even in the same attitude.

Bayonet.—Fixing the bayonet affects the shooting. It lessens the recoil and the jump, but throws out the balance and makes it more difficult to hold the piece steady.

The French regulations say that fixing the bayonet to the Gras rifle deviated the bullets, at 200 metres, 0.5 metre to the left and 0.3 metre low. At the same range, fixing the bayonet on the German rifle threw the bullets of the latter 0.42 metre

to the left and 0.27 metre low, the deviation to the left being due to fixing the bayonet on that side of the barrel.

Rapidity.—The rapidity and duration of the fire affect shooting by exciting and fatiguing the firers, causing them to fear the recoil, and not giving them time to aim.

Definitions.—We may now define the accuracy of the rifle as the greater or less probability which it gives of striking a given object. It is measured by the dispersion of shots due to the rifle alone, and depends on perfection of manufacture.

The accuracy of fire is measured by the dispersion of shots in the group, considering all the causes of deviation.

Correctness of fire is measured by the approximation of the center of the shot-group to the point of aim.

The value of the fire depends on its accuracy and correctness.

Each of the three classes discussed causes a dispersion of shots independently of the others.

The errors due to the rifle and ammunition are least, but they are ineradicable. Those due to the firer and to external conditions may be much reduced by proper instruction, and under favorable conditions, when the ranges are known, the men cool, and the result of the shots can be watched and corrected, may seem almost eliminated. But these means cannot be used in war.

Result.—Under the conditions of battle the result of the shot and the degree to which these several causes have influenced that result, are entirely unknown, and in the effort to make a possibly needed correction the soldier, without info-

TABLE hforth's formulæ.

RANGE IN YARDS.	Angle	DRIFT, INCHES.*	MAXIMUM ERRORS.	
			Vertical.	Horizontal.
100	11'	1.3	0.22	0.22
200	24'	3.00	0.45	0.41
300	40'	5.1	0.70	0.61
400	58'	7.8	0.99	0.85
500	1°17'	11.5	1.32	1.06
600	1°39'	16.10	1.65	1.32
700	2° 4'	21.9	2.10	1.67
800	2°31'	28.35	2.53	1.95
900	3° 1'	35.7	3.16	2.35
1000	3°34'	43.2	3.78	2.70
1100	4°10'	51.0	.....	.....
1200	4°48'	59.3	.....	.....
1300	5°48'	68.4	.....	.....

* Very nearly

TABLE I.---Approximate Trajectory of

LOCITY.	TIME OF FLIGHT.
74.75	.24..
86.4	.51
93.0	.8027
39.6	1.114
97.22	1.44
58.4	1.78
21.8	2.14
87.5	2.514
55.0	2.91
34.5	3.31
95.5	3.72
88.0	4.18
41.8	4.64
me	

mation or guide, may make worse what will already be bad enough. To all the causes we have discussed will then be added the excitement and haste which men must feel under fire, and the sum of all will cause a dispersion which makes the "accuracy" of the fire a doubtful expression. Therefore, in discussing the hope that any shot will make a hit in battle, we need some predetermined guide. We have seen that the errors of the rifle are ineradicable, but they are determinable. The errors due to the other causes are in the field entirely indeterminate, both in direction and in extent.

Conditions of a Hit.—If we assume as a hit, for purposes of our discussion, every shot which might be one, if the firer and the external conditions were both perfect, and as a miss every shot which the error of the rifle alone might cause to miss, we have the only definite rule which can be laid down. Our estimate will be liberal enough, since we thus exclude the greatest sources of error.

First Principle.—This, then, is our first principle. We altogether neglect the errors due to imperfections in the firer and to external conditions, and consider only those of the rifle and ammunition; and we seek to compensate in some measure for this, by considering no shot a hit which the latter errors might cause to miss.

CHAPTER 3.—MEAN AND PRACTICAL TRAJECTORY.

Distribution of Hits.—The deviations due to the causes discussed may in a single day's shooting tend more in one direction than in any other. For example, the wind on any given day may blow constantly from the left, throwing the shots more or less to the right; but the firer, in applying the wind-gauge to correct this, may make an excessive allowance, and thus throw the shots again to the left; and in action, where he is not informed of this error, he has no means of correcting it.

Cone of Trajectories.—And when we consider a large number of shots, fired under varying conditions, the causes of deviation are as likely to act in one direction as in any other. Even if we consider only the errors due to the weapon and ammunition, we see that we cannot fire along any single trajectory, but that the shots in their flight form what may be considered a cone of trajectories, analogous to the jet of water from a hose, with a cross-section increasing with the distance from the origin. There is an imaginary curve which occupies a mean position among all these trajectories. It is called the mean trajectory, and is that which the projectile would probably have followed had the causes of deviation not existed.

This mean trajectory is the one to which calculations are usually referred, and is the trajectory worked out by Bashforth's tables.

Practical Trajectory.—This mean trajectory gives the mean height of the bullets above the line of sight at any point of their flight, while the cone formed by the mean trajectory surrounded by the remaining trajectories allows us to calculate the chances of striking an object of given dimensions at a given range. This may be called the “practical trajectory,” and is that which we must consider in discussing the efficacy of individual fire.

The ordinate of the mean trajectory at any point is the mean of the ordinates of all the trajectories at that point.

Shot-Groups.—Now suppose the cone of trajectories cut at various points by vertical targets: the surface covered on the target by all the shots at each range will be the “*shot-group*” for that range.

Law of Distribution.—These hits, forming the shot-groups, appear at first to be distributed without regularity, but as the number of hits increases we will find that they follow a certain law.

The hits are denser around a mean point which marks the mean trajectory.

If we draw any line through this point, and other lines parallel to it, and at equal distances on each side, the zones which are equidistant from the central line will contain the same number of hits, and this number will decrease as the distance of the zone from the center increases. As the number of hits increases, the form of the shot-group, omitting a few abnormal hits, constantly approaches that of an ellipse with the greater axis vertical.

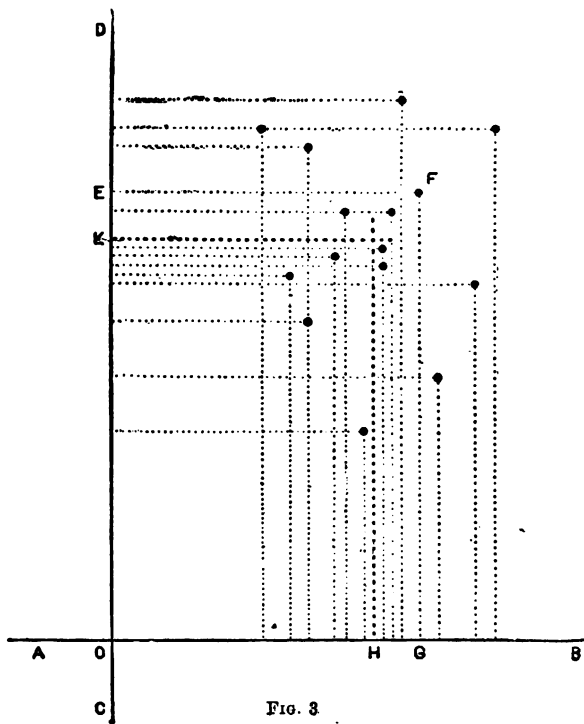


FIG. 3

Center of Impact.—The point where any shot strikes the target is its “point of impact.”

Draw through any convenient point, O, two straight lines, AB and CD (Fig. 3). Draw from each point of impact in the group a line parallel to CD (as FG). We thus determine the distance of each point of impact from O, measured on AB. Draw similar lines parallel to AB (as FE), and thus determine the distance of each point of impact from O, measured on CD.

Find the mean of the first set of distances, lay it off from O on AB, and through the extremity (H) draw a line parallel to CD. Lay off the mean of the second set on CD, and draw through the extremity (K) a line parallel to AB. The two lines last drawn will intersect in a point, having a mean position in the group, and called the “center of impact.” It is the point where the mean trajectory would strike the target.

The horizontal distance of any hit from this point is its “horizontal deviation,” and its vertical distance its “vertical deviation.”

Measure of Accuracy.—The mean of all the deviations due to the rifle in each direction will measure the accuracy of the rifle in the corresponding direction. The square root of the sum of the squares of these two means gives the “mean absolute deviation,” that is, the average distance of the shots from the center of impact. This “mean absolute deviation” is the measure of the accuracy of the rifle, and gives a standard by which different weapons can be compared. In England it is called the “figure of merit” of the rifle. The deviations at

each range determine the dimensions of the shot-groups at the range. The position of the shot-group on the target will be determined by the correctness of fire. If the latter is so correct* that the center of impact coincides with the point aimed at, the mean absolute deviation will show the mean error actually to be expected.

Correctness and Accuracy Illustrated.—We must add to these deviations, therefore, those due to errors in aiming or in the adjustment of the sights, which cause the whole shot-group to be placed wide of the point aimed at. These arise from many causes, already discussed, and make it doubtful whether a hit will be made at unknown distances, even with the most accurate rifle. This gives additional strength to the conclusion of the last chapter, that we cannot rely on any fire in which the error due to the rifle alone would cause the shot to miss; for we cannot absolutely rely even on a fire where the accuracy of the rifle is sufficient to cause every shot to strike the object aimed at.

For example, take four shot-groups all directed at the same point, A.

If the center of impact of each were sure to coincide with A we might, in calculating the chances of a hit for any shot, con-

* If the sights themselves be not true, they may be adjusted: so that the position of the center of impact will depend, as stated, on the correctness of the fire. But this in its turn depends on a knowledge of the proper adjustment; so that the position of the shot-groups is a very variable thing.

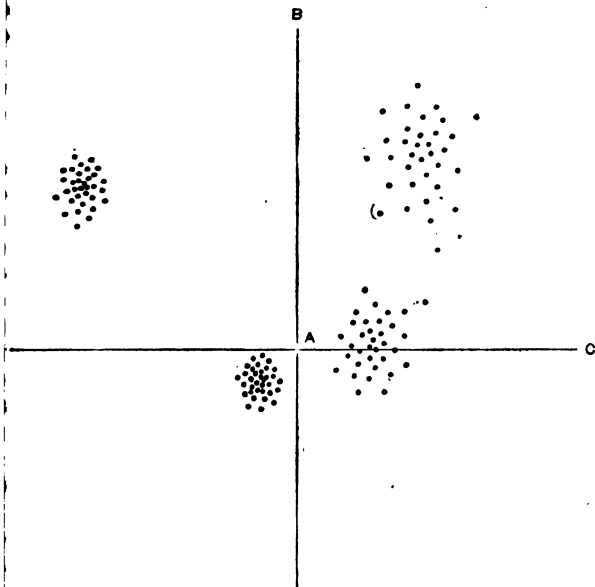


FIG. 4.

Under the mean absolute deviation for each group, and perhaps proceed on the assumption that external conditions could be so neutralized, and the errors of the firer so nearly eliminated.

that the mean deviation would not exceed that due to the rifle alone. But atmospheric variations, errors of elevation and defects in the firer all conspire to displace the shot-group; and when we consider how slight is the probability that the center of impact will coincide with A, we see that the limit we have adopted is more likely to be too broad than too narrow; for the probability of hitting the mark depends both on the dispersion of the shots in the group (*i. e.*, the accuracy of the rifle) and on the distance of its center of impact from A; but in our discussion we have assumed that this center of impact will always coincide with A.

Rigidity of Trajectory.—Every trajectory may be considered to include the trajectories of the lower ranges. This principle, known as that of “the rigidity of the trajectory,” is not strictly true, but the error arising from its application to rifle firing is not appreciable. Hence, if we trace the trajectory of any long range, say 1000 yards, the different portions of the trajectory corresponding to less ranges will be the trajectories of those ranges. The trajectory here referred to is the mean trajectory, passing through the point of mean impact.

If ellipses be drawn at the various ranges, each with its center in the mean trajectory, and having horizontal and vertical axes, respectively, equal to twice the greatest errors of the rifle for that range, these ellipses will include all the shots.

Cone of Fire.—If now we join the circumferences of these ellipses, we obtain a solid curved cone, which represents the whole bundle of trajectories. The axis is the mean or theoretical



FIG. 5.

ical trajectory. The extreme elements of a vertical section through the axis are the trajectories of the bullets having the greatest vertical deviation. The extreme elements of a horizontal section through the axis are the trajectories of the bullets having the greatest horizontal deviation.

Representation.—The effect on the shooting of vertical errors being practically so much greater than that of horizontal errors, it is sufficient, for practical purposes, to represent the trajectory by the vertical section, showing the mean and extreme trajectories.

Expression of Trajectory.—The form of this cone is expressed by stating the ordinates of the extreme and mean trajectories, the ordinate being the vertical distance from the line of sight. Having given the ordinates of the mean trajectory and the greatest errors, the ordinates of the extreme trajectories may be deduced, by adding the greatest error to the corresponding ordinate of the mean trajectory, for ordinate of the upper trajectory, and subtracting the same error, for that of the lower trajectory.

Position of Shot-Groups.—The center of the shot-group being in the mean trajectory, the ordinates of this curve will

determine the position of the shot-groups with respect to line of sight. The height of the center of the shot-group above the ground is equal to the corresponding ordinate of the mean trajectory, plus the height of the corresponding point of line of sight above the ground. For example:



FIG. 6.

AB—height of center of shot-group above line of sight.

AB+BC—height of same above ground.

Dangerous Space.—The dangerous space is that within which the object may be struck. The theoretical dangerous space is that in which the mean trajectory is within the height of the object. For the reasons already stated, the practical

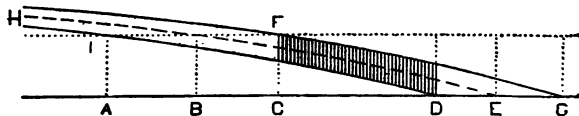


FIG. 7.

GF, Upper trajectory. HE, Mean trajectory. ID, Lower trajectory.
BE, Theoretical dangerous zone, or dangerous zone for mean trajectory.
CD, Practical dangerous zone, or zone grazed by the whole cone.

dangerous space for individual fire should be considered only as that in which the whole cone is within that height.

Ricochets.—The extent of this zone will, in nearly all cases, be increased by ricochets; but the results actually to be expected are so much less than those which would theoretically follow, even from the narrow limit we have taken, that it seems better to omit calculations based on anything so uncertain as ricochets.

It is not true that the object will never be struck outside of what we have taken as the practical dangerous zone, but such hits will be scattering; and since any bullet is liable to follow either the upper or the lower trajectory, since we cannot tell which of these it will follow, nor in battle which it has followed, and since the resulting uncertainty is aggravated by other causes of error, the results gained must be so unreliable that they will not in practice compensate for the expenditure of ammunition, and should, therefore, be disregarded.

Therefore we consider that an object will be struck by individual fire only if it is within the practical dangerous zone.

Range Over-Estimated.—Suppose that the range has been over-estimated; that is, that the object is at some distance less than that corresponding to the elevation used.

If aim be taken, with any elevation, at the bottom of an object, situated at varying distances between the origin of fire and the supposed distance, since the foot of the object is in the line of sight, the ordinates of the mean trajectory for the elevation used will give the height of the center of the shot-group on

the target, for each of its positions. If any point except bottom be aimed at, the height of this point must be added to the ordinates, in order to get the height of the center of shot-group.

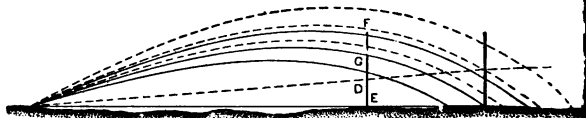


FIG. 8.

G, Center of shot-group, aiming at bottom of target.

F, Center of shot-group, aiming at point D.

$DF = EG$, and

$FE = EG + DE$.

The trajectories are identical. The height of the center of the shot group, aiming at the foot, is GE , the ordinate of the mean trajectory; aiming at D it is EF , the ordinate of the mean trajectory plus the height of the point of aim.

The height of the point of impact is independent of that of the origin of fire, from the very small angle between the line of sight.

But the extent of the dangerous zone depends materially on the height of this origin. In an experiment made with a German (Mauser) rifle, fired from the standing and kneeling

positions, the latter gave at 400 metres a zone 50 metres greater than that given by the former, with more effective ricochets.

Table 2 gives the height above the ground of extreme trajectories, at intervals of 50 yards in distance, on the following suppositions:

Elevation, 400 yards.

Ground parallel to the line of sight.

TABLE III.

DISTANCE.	UPPER TRAJECTORY.		LOWER TRAJECTORY.	
	Bottom.	Center.	Bottom.	Center.
50	2.00	4.75	1.78	4.53
100	3.62	6.37	3.18	5.93
150	4.80	7.55	4.12	6.87
200	5.46	8.21	4.56	7.31
250	5.49	8.25	4.35	7.10
300	4.82	7.57	3.42	6.17
350	3.32	6.07	1.62	4.37
400	0.99	3.74	-0.99*	1.76

* Indicating that this trajectory, if unobstructed, would be the given distance below the foot of the target.

Proper Point of Aim.—From this table we can deduce the fact that the proper normal point of aim is the foot of the object.

1. Because as the enemy comes nearer, the line of sight inclines more and more toward the ground, which reduces the danger that the men in their excitement will fire too high. This result is not obtained, except from the standing position, when aim is taken at the center of the object. Taking the total height at 5.5 feet, the height of the center is 2.75 feet. For the kneeling position the height of the origin is nearly the same, giving a line of sight nearly horizontal, while for the lying position the height of the origin is about .89 foot, giving a line of sight inclining upwards.

2. Aiming at the foot gives a more advantageous position to the shot-groups, and increases the practical dangerous zone.

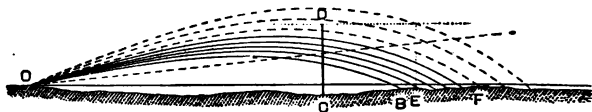


FIG. 9.

Taking the target in the position CD, if aim be taken at the bottom, the whole shot-group falls on the target. If aim be taken at the center, only half the shot-group strikes it.

If aim be taken at the foot, the practical dangerous zone extends from O to B; if at the center, only from E to F.

3. The ground is better covered, since there is less space in which the bullet rises above the height of the object.

4. The ricochets from the lower half of the cone are effective.

A ricocheting bullet rises at an angle equal to about twice that of fall. If the mean trajectory strikes the foot of a target 5.5 feet in height, the ricochet from the lower trajectory will throw the bullet into the target up to very considerable ranges.

5. Slight increases of elevation are not so likely to cause the shot to pass completely over the object as when aim is taken at the center.

6. The fore-sight covers about half the height of a standing man at 200 yards. If aim be taken at the center, the object may be completely hidden by a slight upward movement of the barrel. This is not likely to occur at ranges less than 400 yards when aim is taken at the foot.

7. It is tactically advantageous.

The tendency to fire high is to a certain degree checked by training the soldier to aim at the foot.

If the object is covered with smoke, as it will be soon after the battle begins, the center cannot be determined, and the only definite point of aim is the intersection of the bank of smoke with the ground. It should be constantly borne in mind that our object is not to hit the enemy in any particular part of the body, but to hit him somewhere, and that we should aim at that point which gives the greatest hope of making a hit.

All European nations agree in selecting the foot as the point to aim at, and our own Firing Regulations say :

"Care should be taken to aim at the feet of the enemy. This selection of a point of aim is in fact, except when the enemy is within short range, especially advantageous, as,

when it is employed, a greater number of the bullets in the shot-group will usually prove effective, and as, moreover, the line of separation which exists between the cloud of smoke and the ground offers the best-defined object; and also the error so common in the heat of action of taking too full a sight is neutralized."

Yet in spite of all this, our whole training is directed toward teaching the soldier to aim at the center. Since men should aim, in action, at the bottom of the object, they should be trained, at all times, to aim at that point.* There is much to be said in favor of adopting a target similar to that used in Europe, instead of that now used by us in known-distance firing, which has no resemblance to any objective against which we will wish to fire. The English target, for example, is simple, cheap, and similar in appearance, at a distance, to a man, and by suitable combinations can easily be made to represent various formations.

Perhaps a still better plan would be to retain our present targets, but place them so that the point of aim (the bull's-eye) would appear at the bottom. At any rate, whatever the means adopted, the soldier should certainly be trained to aim at the foot of the target.

*If the range is accurately known, and it is for any reason desirable to raise the shot-group on the object, a slight increase of elevation will suffice for that purpose,

CHAPTER 4.—LIMIT OF INDIVIDUAL FIRE.

Now to deduce a limit for individual fire—that is, a limit beyond which the results to be expected will not compensate for the expenditure of ammunition. This limit depends on several considerations.

TABLE IV.

RANGE.	VERTICAL.	HORIZONTAL.
100	0.22	0.22
200	0.45	0.41
300	0.70	0.61
400	0.99	0.85
500	1.32	1.06
600	1.65	1.32
700	2.10	1.67
800	2.53	1.95
900	3.16	2.35
1000	3.78	2.70

Relation between Shot-Group and Object.—1st. On the relation between the dimensions of the objective and those of the shot-group. From the principle already adopted (page 33), the limit of profitable individual fire is reached when the shot-group becomes equal to the object in either dimension.

Size of Shot-Groups.—Table IV gives the vertical and horizontal errors for the Springfield rifle.

It will be observed that the vertical errors exceed the horizontal. This excess is at first slight, but increases with the range, being at 800 yards about 30 p. c. of the horizontal deviation. Consequently, an increase in the breadth of an object without increase in its height, does not, in general, increase the probability that it will be hit by a single man.

Before finding these errors for their rifle, the Germans deduct a certain percentage of hits for abnormal shots. The reason for so doing is not stated, but the numerous experiments made have, without doubt, shown that it is necessary.

These percentages are :

At 100 metres, 1 p. c.; at 150 m., 2 p. c.; at 200 m., 3 p. c.; at 250 m., 4 p. c.; at 300 m., 5 p. c.; at 350 m., 6 p. c.; at 400 m., 7 p. c.; at 500 m., 8 p. c.; at 600 m., 9 p. c.; at 700 m., 10 p. c.; at 800 m., 11 p. c.; at 900 m., 12 p. c.; at 1000 m., 13 p. c.; at 1100 m., 14 p. c.; at 1200 m., 15 p. c.; at 1300 m., 16 p. c.; at 1400 m., 17 p. c.; at 1500 m., 18 p. c.; at 1600 m., 19 p. c.

Dimensions of Objectives.—The generally received dimensions

ions of the usual objectives met in war may be stated as follows :

Height of man standing.....	5.5	feet.
Height of a man running forward.....	5.33	"
Height of a man kneeling.....	3.67	"
Height of a man lying down in the open..	1.50	"
Height of a man lying down under cover..	1.17	"
Height of a horseman standing.....	8.00	"
Height of a horseman riding rapidly.....	6.67	"
Total width of a man.....	1.75	"
Width of the vulnerable part of a man...	1.33	"
Width of a group of 2 men in close order..	4.1	"
Width of a group of 3 men in close order..	6.45	"
Width of a group of 4 men in close order..	8.8	"
Width of a horse and rider.....	3.00	"

Comparing these with the errors in the table, we can deduce the first of our limits for profitable individual fire.

Examples.—Suppose the object to be a single man standing. If the range be accurately known, and aim be taken at the feet, the limiting distance is that at which the vertical error is 5.5 feet, (since this will bring the whole shot-group within the height of the object,)* or at which the greatest horizontal error is $1\frac{2}{3}$, or 0.67 feet, (since this will bring the whole shot-

*This is based on the fact, already stated, that when aim is taken at the feet the ricochets from the lower half of the cone are effective. In all the examples taken, a different result would be obtained if we supposed aim to be taken at the center of the target.

group within the width of its vulnerable part; and the limit will be determined by the error which first reaches these figures.

The vertical error of 5.5 feet corresponds to a range of about 1200 yards; the horizontal error of 0.67 feet, to a range of about 350; hence the limiting range of individual fire, against a single man standing, may be taken as 350 yards for the Springfield rifle, and the limit for any other rifle may be calculated in the same way.

Suppose the object is a single man lying down in the open, aim taken at the bottom of the object. The limit will correspond to a vertical error of 1.50 feet, or a horizontal error of 0.67 feet. The former gives a range of about 550 yards, and the latter one of about 350; and the latter may again be taken as the limiting distance for individual fire.

Suppose the object is a group of two men kneeling; limiting vertical error, 3.67 feet; horizontal, $\frac{1}{3}$, or 2.05 feet. The former corresponds to a range of nearly 1000 yards, the latter to one of about 800 yards; hence, 800 yards may be taken as the limit.

Suppose two men lying down in the open. Limiting errors—vertical, 1.50, horizontal, 2.05 feet. The former corresponds to a range of 550 yards, the latter to a range of about 800; and the limit will be the shorter distance.

These figures will change whenever either object or rifle changes; but the principle remains the same—that profitable individual fire reaches its limit at the range at which the greatest vertical error or twice the greatest horizontal error of the

rifle becomes equal to the corresponding dimension of the object.

* These figures depend on exact knowledge of the range, on coincidence between the point aimed at and the center of impact, on favorable external conditions which can rarely exist, (absence of wind, etc.,) and on an entire absence of any error on the part of the firer. In reality, we must divide the results obtained by the best firers by three or four, to find those which can be expected from the mass of men, and then divide this result, according to the French and German practice, by ten, to find their probable value in battle, even for known ranges; a condition which will very seldom arise in the field. Certainly not more than $\frac{1}{30}$ or $\frac{1}{40}$ of peace results can be relied on in war; the Austrians say $\frac{1}{70}$.

2d. The limit depends on the relation between the range and the practical dangerous space.

Range Known.—(a) Suppose the range exactly known. In this case, (since we have agreed to omit, for the present, all errors on the part of the firer and all those due to external conditions,) the center of the shot-group coincides with the bottom of the object, and the depth of the dangerous zone does not affect the question, provided such a zone exists. With the Springfield rifle, 800 yards is the longest range at which such a zone is found; hence, if the object is of suitable dimensions, as, for instance, a group of two men kneeling, and the range is exactly known, 800 yards may be taken as the limit of individual fire for that weapon.

Range Unknown.—(b) Suppose the range to be unknown. The limit will depend on the relation between the error of estimation and the depth of the practical dangerous zone, and will be that distance at which these become equal.

The bullet may be in either of the extreme trajectories, and the object may be at any part of the space which denotes the error of estimation. We cannot be sure that the object will be struck if this error is sufficient to remove it from the practical dangerous zone; hence we *pass* the limit when the error of estimation becomes greater than the depth of the dangerous zone.

Examples.—If, for example, the range be measured with a range-finder with an error of 2.5 per cent., the limit of profitable fire will be the distance of which 5 per cent. is equal to the depth of the practical dangerous zone.* For the Springfield rifle, the dangerous zone at 600 yards range may be taken as 25 yards. Five per cent. of the estimated range is 30 yards; hence this limit, under these circumstances, would be a little less than 600 yards.

If the range is estimated by the eye alone, $\frac{1}{8}$ may be taken as the average error, and the limit is the distance of which $\frac{1}{4}$ is equal to the depth of the dangerous zone.* At the estimated range of 500 yards, the error would be 125 yards, and the depth of the practical dangerous zone 48 yards, which does not nearly

*Since the error may be on either side of the truth—that is, either of excess or of diminution.

compensate for the error. At the estimated range of 400 yards, the error is 100 yards, the dangerous zone 400 yards, and the limit is about 450 yards.

Covering of Ground.—3d. The limit depends on the covering of the ground. "In a battle which is intended to be fought to an issue, one side must act on the offensive, the other on the defensive; these roles may be interchanged, but at any given moment the opposing front lines of the adversaries must be either advancing to the attack or standing to receive it; therefore the distance between the two sides tends to diminish, and it becomes most important that the space intervening between the adversaries should be swept by a storm of bullets. The ideal of rifle-fire in the field is reached when no bullet in the intervening space passes above the head of a standing man—that is, when no bullet rises higher than 5.5 feet above the ground."

We have already seen, from Table I, that with the Springfield rifle this condition is fulfilled at the 400 yards range, if aim is taken at the feet, and at no greater range; hence 400 yards is the limit of profitable individual fire for that arm; and the limit for any other may be found in the same way.

RESUME.

We have found that the limit of profitable individual fire depends on four considerations:

1st. It is reached when the shot-group equals the objective in either dimension; but with a rifle as accurate as the Springfield this relation becomes unimportant, since, so long as aim

is taken at the feet there is hardly a case in which this limit will apply. It is true that we found the limit to be 350 yards against a single man standing, on account of the horizontal error, but at so short a range the objective, in battle, will almost always have a very different width.

2d. It is reached when the dangerous zone (due to the whole cone) disappears, even if the range be exactly known.

3d. It is reached when the probable error in estimating the distance becomes equal to the depth of the dangerous zone.

4th. It is reached at the range where the bullet begins to rise above the head of a standing man at any point of its flight.

The first we have eliminated. The second applies only to the rare case where the range is exactly known, and fixes the limit for that case at 800 yards. The third and fourth apply to the general case of an unknown and estimated range, the limit from the third cause being about 450, and from the fourth, 400 yards, both based on the supposition that aim is taken at the feet. The limit for profitable individual fire with the Springfield rifle is, therefore, 400 yards.

This may appear a very narrow limit; but it is constantly to be borne in mind that we have considered, in deducing it, only the errors due to the rifle, and have supposed the external conditions perfect, and the firer to make absolutely no error.

Error of Firer.—To illustrate the effect of the firer's errors, take the case where he makes the small error of 10 minutes of arc in aiming, by a slight upward movement of the piece at the moment of firing. This will cause a vertical error in the post-

tion of the line of sight of .873 foot for each 100 yards of distance. The displacement at 200 yards will be 1.746 feet; at 250 yards, 2.1825 feet, and at 300 yards, 2.619 feet. Adding these to the ordinates of the upper trajectory at these ranges, we get the height of the bullet, if the 400 yards elevation is used—

At 200 yards, 6.846 feet;

At 250 yards, 7.082 feet; and

At 300 yards, 6.719 feet;—

enough to cause the bullet to pass completely over the heads of a line of standing men.

Theoretical and Practical Shot-Groups.—It might at first appear that this error might antagonize and counterbalance the error of the rifle; but this supposition involves a combination of circumstances which will very rarely occur, and which is more than neutralized by the other causes of error which we have omitted from the discussion. In other words, the shot-group in practice, even the best practice, is much greater than the shot-group due to the errors of the rifle alone, which we have been discussing, and the remote possibility of compensating errors will still leave us a shot-group greater in every dimension than that on which we have based our limit.

German Opinion.—The Germans say, from the preceding discussion, that nothing is to be expected beyond 800 yards when the distance is exactly known, or 400 yards when the distance is estimated, from the fire of single men, because beyond these limits the skill of the firer cannot counterbalance

the unfavorable influences independent of his action. They consider individual fire at ranges longer than these a mere waste of ammunition. They particularly insist on the fact that in war the object and firer are not stationary, but subject to movement at very short intervals of time; hence that the conditions vary with every shot, so the individual soldier cannot fire under identical conditions a sufficient number of shots to form a cone of any density, and we can properly consider only the single shot, liable to follow any trajectory between the upper and the lower.

French.—The French say: “A sight graduated up to high ranges, (say beyond 1000 yards,) is a permanent source of danger for imperfectly trained troops, commanded by inexperienced officers. They should be taught that this sight is only meant for some rare and very particular cases, such as sieges, where ranges can be accurately measured and effects watched, and that in the field, after 800 yards, (putting down the outside limit,) the individual fire of skirmishers has no efficacy, while under 600 yards it is dangerous, and its effect is decisive as soon as we are within 400 yards.”

Limit of Ammunition.—In what we have said, we do not mean that no hits will be made by individual fire beyond the limit deduced, but that our limit is that of *profitable* individual fire. If the supply of ammunition were absolutely unlimited, and the endurance of the man were sufficient to enable him to fire all the cartridges he had, the limit would lose its importance, and we could afford to fire away at any and all distances.

Take the first of these considerations. Any rifle at present in use will certainly fire eight shots per minute. If fire be opened at 1200 yards from a position, (a distance which it will take, considering halts, some 18 minutes, at least, to cross,) each man on arriving at the position will have fired 144 shots. This is just 44 more than the greatest number carried by the soldier in any European nation—the German; and we may be sure that they have given the soldier all the cartridges he can carry.

Physical Endurance.—Take the second consideration. The fact that the physical endurance of the soldier has a limit, need hardly be stated. Anyone who has fired 40 rounds in the course of a morning's shooting knows that shooting is hard work. Major Mayne mentions the case of a man who fired 60 rounds in succession and had to go to the hospital for some time afterwards; and one of an old soldier, a crack shot, who fired so many as to reduce his shoulder to a "jelly."

Consequently we want to find the limit of that individual fire which gives a fair return for the expenditure of ammunition which cannot be replaced, and for the wear and tear on the muscles and nerves of the soldier; and that limit is the one we have deduced—400 yards for the Springfield, or, for any rifle, the greatest range at which the bullet remains, during its whole flight, within the height of the objective.

Special Cases.—There is one case, however, in which individual fire may be profitable beyond the limit deduced. In the siege, where the enemy's batteries are within the range of

the rifle, and distances are known or can be accurately measured, long-range fire may be used, for the soldier, behind cover, can rest his rifle and fire perhaps 200 rounds without much fatigue; and ammunition can be supplied to him in any quantities.

In outpost or in advance or rear guard work, individual fire may under certain circumstances be used at almost any range; but in these cases the fire is mainly intended as a signal or for intimidation, and little other result is expected.

Ammunition and Effect.—A comparison of the amount of ammunition expended in any war with the number of killed and wounded shows that the number of rounds fired, for each man hit, is to be reckoned by hundreds. This would not be true if results in war were at all nearly equal to peace results.

Mayne quotes estimates by two French writers of the number of rounds required by an average shot at different ranges to put an isolated standing enemy “hors de combat.”

Range in metres	200	300	400	500	600
Number of rounds	13	16	30	47	112
Number of hits .....	.....	5 to 6	10 to 12	14 to 16	30 to 34

There is an old saying to the effect that it takes a ton of lead to kill a man.

Shallow Formations.—From the comparatively great depth

of the dangerous zones we see that deep formations must suffer more than shallow formations, like lines. The difference is so great that the latter must always be used under effective fire.

Economy of Ammunition.—"There is an absolute necessity in the field to take account of the consumption of cartridges, from the great difficulty of supplying them under fire. If the soldier begins to fire at 1400 yards, he will have time to consume almost all his ammunition before producing any serious effect. Disregarding a few slight losses, the enemy will advance in an extended formation up to 600 yards, at which distance he will begin to experience serious loss. If his soldiers have fired but little, they will begin at this distance a fire which will be almost decisive, from the moral and material effect it will have; the former, because the soldier, who sees that his fire does not stop the enemy, gets nervous and loses confidence in his arm; the latter, because the enemy has the greater number of cartridges to fire, and by keeping up a careful fire at 600 yards and under, may use up his opponents' cartridges, and then advance. The side which has used up all its cartridges is lost, and perhaps destroyed, without the possibility of replying.

A disordered rapid flight cannot save it, for bullets travel faster than legs, and in the time a man takes to run 400 or 500 yards (say two minutes), he can receive 20 shots from an adversary, who aims at his ease, as he runs no danger. It will no longer be a fight, but a massacre."

Examples.—The French regulations of 1875 laid down the distance at which fire might be opened in the attack at 600

yards, which is more remarkable from the fact that the French used a general individual long-range fire at from 800 to 1500 yards with some success, under certain favorable circumstances, in 1870-71, especially at St. Privat.

They did not find their success at long range compensate for the shortness of ammunition in the decisive stage of the fight.

Want of ammunition has often caused an attack to cease, as well as a position to be abandoned.

In the war of 1870-71, no useful effect was gained by the long-range individual fire of the French against the German extended formations. It certainly caused serious losses to closed masses, but it had comparatively little effect on the German infantry in dispersed order, so that this infantry could always advance up to 400 yards (then the maximum range of their rifle) and there open fire, without much disadvantage. The same remark applies to the long-range individual fire of the Turks, and the attacks made by the Russian infantry in 1877-78.

For the attack, fire at long ranges is a negation of the offensive, and should for this reason also be avoided as a general practice.

Skirmish Practice.—If the limit herein deduced seems small to anyone, when contrasted with the high percentages made in our service at skirmish practice, it must be remembered that these percentages are made under conditions which practically convert this practice into known-distance firing, at ranges under 600 yards. The run commences at a point known to every man in the firing-line to be 600 yards from the target;

there is no reason why any man should at any time be ten yards in error in his estimate of the range at which he is firing; the targets are placed to give the firer the clearest possible view of them; and returning over the same ground, the last shots of the run are fired at less than 600 yards range. These conditions are not very much like those of real unknown-distance firing.*

*See Appendix.

CHAPTER V.—COLLECTIVE FIRE AND COMBINED SIGHTS.

If then, individual fire, beyond the limits deduced, be not only unprofitable, but a source of danger, from the likelihood that ammunition will be exhausted, and thus induce disaster, what shall take its place? It need hardly be stated that, both in defense and in attack, many shots will be fired while distances greater than 400 yards separate the combatants. Any attempt to prevent this entirely would be dangerous to discipline, as must anything be which leads to an unpunished violation of orders. The answer to the problem is to be found in controlled * fire—that is, in fire which is under such direction that the bullets, instead of being scattered over a multitude of objectives, limited in number only by the possibility that several men may choose the same object, are concentrated on chosen objectives, at which the men must fire.

This is not intended to mean that in controlled fire the men must all fire at an indicated man, or even at exactly the same spot on the group of men. On the contrary, if the object chosen be of any considerable dimensions, each man's fire will

* Collective fire being impossible without control, and controlled fire being naturally collective, the terms may be used interchangeably to designate a fire not necessarily simultaneous, but regulated and concentrated.

naturally and properly be directed on that part of the group which he can best see to aim at.

Collective Groups.—When a body of men fire on the same object, with an elevation nominally the same, neither the men nor their rifles being absolutely alike, the bullets, from the causes already considered, will be spread over a considerable space, especially in the direction of the fire. There results from this a bundle or cone of trajectories, analogous to that formed by the fire of individual men, but of much greater dimensions in all directions. The groups made by the intersection of this cone with any target, vertical or horizontal, may be called collective groups. It is difficult, from their size, to collect them on a vertical target, and it is usual to note the groupings of the shots on the ground, in order to study their distribution, and to ascertain the dimensions of the efficacious or beaten zone which includes any given percentage of the shots.

Law of Distribution.—The general form of these groupings will be that of an ellipse, having its greater axis in the direction of the fire. The hits in this ellipse will be found most densely grouped toward the center, just as in the individual shot-group.

When the ground is parallel to the line of sight, the depth of the zone containing all the shots is found to decrease as the distance increases.

Depth of Beaten Ground.—If a sufficiently large number of bullets be fired, at different ranges running from 500 to 1400

yards, and 90 per cent. of the hits be considered (deducting 10 per cent. for abnormal hits), then the average depth of the beaten zone for 90 per cent. is about 300 yards at the shorter range, and 200 yards at the longer. At ranges greater than 1400 yards, the depth of the beaten zone for 90 per cent. of the hits begins to decrease more rapidly.

If we consider only the densest part of the group, containing the best 50 per cent. of the shots, the beaten zone is about 150 yards at 500, and 100 yards at 1400 yards; half these distances in front and half in rear of the center of impact, which should correspond with the range.

Definitions.—The zone containing the best 50 per cent. of the hits is called the nucleus; that containing the next 40 per cent., the envelope; and the rest of the beaten zone, the tailing. The middle line of the nucleus, parallel to the front of the firing-line, is the “center of impact.”

The total depth of the beaten zone for collective fire decreases as the range increases, because the angles of elevation increase more rapidly than the corresponding ranges. For example, an error of 1° too much elevation at 100 yards makes the bullet go 400 yards further, while the same error in elevation at 2100 yards makes the bullet go only 100 yards further. Thus the longer the range, the less does a given small error in elevation affect the range,* and consequently the space over which the

*The direct contrary of this is true of bullets falling on a vertical target, for in that case a given small error of elevation causes a rapidly increasing error in the height of the point struck.

bullets fall, therefore the longer the range the less is this space.

At the shorter ranges, the mass of the bullets fall near the center of impact, while, at the longer ranges, they are more evenly distributed over the beaten zone; and thus it is that the central 50 per cent. of the hits fall in about the same space of 100 yards at all ranges from 500 up to 1400 yards.

Experiments made in Belgium in 1881 and 1883 showed that:

With average men, the best 50 per cent. of the shots were spread over a depth of 150 metres, at ranges less than 1000 metres; over 100 metres, at ranges between 1000 and 1400 metres; and over 125 metres, at ranges greater than 1400 metres. This last result is really due to a change in the manner of sighting.

With trained and chosen men, the best 50 per cent. of the shots covered 100 metres at all ranges.

The French Regulations say: "The depth of the beaten zone is sensibly constant, whatever the distance of the object may be; it is about 100 metres if the best 50 per cent. of the hits, or the densest part only of the grouping, be considered." These numbers are not absolute, and can increase or decrease with the skill of the men firing.

Variations.—Variations in the depth of the beaten zone will also arise from other influences, such as fatigue, excitement, the inclination of the ground, &c. "It is dangerous to rely on deductions found by calculation alone as to the proba-

ble effect of fire. Experiment must be added before we can arrive at results worthy of confidence."

The numbers given are average ones, and are by no means absolute, but may vary with the skill of the firers and the circumstances of the firing; as, for instance, with the use of rests. But with trained men the dispersion in depth remains independent of the distance, (if a sufficient number of shots be fired,) though it varies with the inclination of the ground on which the bullets fall, as will be shown later.

Instruction.—The conclusion to be drawn from these facts, is that infantry should be instructed in collective firing as carefully as they are in individual firing, and that the principles of fire discipline should be instilled into officers and men, by which alone collective fire is made possible. Suggestions as to means and methods for this purpose will come in a subsequent chapter.

Width of Beaten Ground.—The width of the ground beaten when a single point is aimed at increases with the range. The French regulations say that when all the rifles are directed on the same point, the width in yards of the group, for the best 50 per cent. of the hits, between 500 and 1500 yards, is about equal to the number of hundreds of yards in the range (*i. e.*, 5 yards at 500 yards, 10 yards at 1000 yards, etc.). It is 30 yards at 2000, and 60 at 2400 yards. The width of the groups for 90 per cent. of the hits is about double that for the best 50 per cent.

This increase of width causes a decrease in the density with

which the hits are grouped, and therefore a decrease in the efficacy of the fire.

Determination of Value.—The conditions of individual and collective fire are so different that the probable value of the fire must be worked out differently. The value of the former is based on the extent of the zone grazed by the whole cone; that of the latter, on the extent of the beaten zone and the density of the hits in that zone. We have not the means of laying down for it a limit based on the comparison between probable errors and the size of the target. It is evident, however, that the value of a collective fire depends both on the extent of ground struck and the theoretical dangerous zone of the bullet—that is, on the angle of drop. The less this angle, the greater the number of bullets which come within the height of the target, and the greater the probability of a hit; and thus we are enabled to compare the value of collective fire at different ranges.

The angle of drop increases with the range, while the depth of the nucleus remains nearly constant. If we divide the horizontal distance passed over by the bullet, between first catch and first graze, by the height of the object,* we shall obtain a relative measure of the value of the fire. These figures are given in column 6 of Table I; from which we see that if the lateral dispersion remained constant, the value of a collective

*This might be otherwise stated as finding the horizontal distance passed over in falling a unit in height.

fire, taken as unity at 500 yards, becomes one-half at 800, one-fourth at 1200, and one-eighth at 1700 yards.

Decrease in Value.—But the lateral dispersion must be considered, and taking the French estimate as correct, ~~this will~~ reduce the value of the fire, unity at 500 yards, to about one-third at 800, one-tenth at 1200, and one-thirtieth at 1700 yards. These numbers are not absolute, but will serve to show how rapidly the value of the fire for a given number of shots decreases with the range.

Expenditure of Ammunition.—Thus at known ranges, to get the same efficacy of collective fire at 1200 as at 500 yards, we must expend ten times as much ammunition. This is best done by increasing the number of men firing, since losses suddenly inflicted produce a greater moral effect than those which are spread over a considerable time.

Distribution in Nucleus.—The center of the nucleus is the center of impact for the horizontal group, but the best 50 per cent. of the hits are very uniformly distributed over this nucleus, and in order to fire with the greatest useful effect, it is sufficient to cause some part of the nucleus to fall on the objective. Hence, in dealing with collective fire, a knowledge of the range to within 50 yards (half the depth of the nucleus), is all that we absolutely require.

But increase of range is attended not only by a decrease of efficacy in the fire, but also by an increasing difficulty in estimating the range within 50 yards. Both these causes tend to make the fire less and less efficacious, and there is somewhere

a limiting range, beyond which any fire, though aimed and concentrated, becomes really haphazard, or chance fire.

Limiting Range.—This limiting range must be to some extent a matter of opinion, since no absolute rule can well be laid down on the subject. The war of 1877-78 proved that the chance fire of large numbers of men, even at the distance of 2000 yards, might produce a considerable effect on troops in deep closed formations, but at the cost of an immense expenditure of ammunition. Such fire can have a profitable application only to exceptional cases.

In our calculations, we must bring some part of the beaten zone to fall on the object. What shall we consider as the extent of the beaten zone?

The depth of the nucleus is almost constant, while that of the envelope varies considerably; the former has been taken by most of the European nations, as the result of their experience, which we lack, and in this discussion we will therefore consider the central beaten zone, or nucleus, with its depth of 100 yards, as the efficacious beaten zone.

Range Known.—If the range is known and a sufficient number of shots can be fired, the firing, in theory at least, might be continued up to the extreme range for which the rifle is sighted. But even in such an unusual case, a practical limit will be imposed by the rapidly increasing dispersion of hits.

Range Unknown.—If the range can only be found, by any means, to a certain percentage of the truth, then a body of men, firing with the same elevation, should not fire at any

range beyond that at which the given percentage of error becomes equal to half the beaten zone, or 50 yards; because the error may be either of excess or of diminution, and we cannot be sure that any part of the beaten zone will fall on the object, if twice the error be greater than that zone, or the error greater than one-half that zone.

Make

R=limiting range at which firing is advisable, or likely to be profitable.

E=probable error, as 0.03,

Then $R \times E$ must not be greater than 50 yards, and $R \times E = 50$,

or
$$R = \frac{50}{E}$$

will give the value of R in yards.

Example.—Suppose, for example, the range can be found to within 0.03 of the truth; $R = \frac{50}{0.03}$, or 1666.66, will be the limiting advisable range, that is, the limiting range at which we may expect a reasonable return for any expenditure of ammunition which will ordinarily be possible.

But the enormous amount of ammunition required to give any density to the hits in the beaten zone at such a range will, in practice, reduce this to about 1300 yards; and this may be taken as the maximum range allowable, and then only under very favorable conditions.

Beyond this range, firing should not be attempted, except under very unusual circumstances, such as the possession of a supply of ammunition so unlimited that some of it can be was-

led. This unlimited supply the Turks had in 1877-78, and they certainly got some result from wasting it, though it may be doubted whether better results might not have been obtained by reserving it for closer ranges; and it is always to be remembered that the objects they fired at will rarely be presented, and that, after all, they did not stop the Russians.

Even this range of 1300 yards will rarely be available, from the undulating character of the ground, which allows hostile bodies to approach within a less distance unseen, and might expose one party, while it was wasting ammunition at 1300 yards, to fire at shorter range and of greater efficacy.

If we are reduced, by the absence of other means of information, to estimating or guessing the range, the errors are likely to be very great.* A writer in the *Revue Militaire de l'Etranger* says that the Germans allow $\frac{1}{3}$ of the estimated distance as the probable error in such cases, even when the distance is judged by a number of practiced and skillful observers (never less than four), and the mean of their estimates taken.*

From a consideration of the rules of fire laid down in European armies, it seems that a total of error of one-fourth the truth is allowed for, which supposes an error of one-eighth in judging the distance by the eye.

Substituting this $\frac{1}{8}$ for E in our formula, we have

$$R = 50 \div \frac{1}{8} = 400$$

as the limiting range at which a body of men, all using the

* See Appendix.

same elevation, can be sure of bringing some part of the beaten zone to fall on the object. But with the present rifle we do not need collective fire at this range, as we have already shown.

This allowance of $\frac{1}{8}$ seems too great, at any rate for distances less than 1000 yards. There is no doubt that, without making the practice a burden, to be shirked at every opportunity, a large proportion of our soldiers could be trained to estimate distances within a smaller limit of error, and that the estimates of several of the best trained men might be compared with those of the officers, and a result thus arrived at within .10 of the truth. Even this, however, which seems the best average on which we could rely, would only extend the range to 500 yards.

It seems proper to repeat here, that there is no intention to deny that some hits would be made by the envelope, and perhaps some by the tailing; but such hits would be matter of accident, and entirely unreliable, and the effect they would produce would not repay their cost in ammunition.

Combined Sights.—Beyond this 500 yards, we are confronted by two contradictory desiderata: to be sure of getting some result from our fire, (that is, to be sure of making some part of the beaten zone fall on the object,) and to get the greatest result from that fire, supposing that it does so fall.

The first of these may be attained by increasing the depth of this zone until it becomes equal to the probable error. To do so (supposing the range estimated by the eye) we must divide the body of men firing into two or more parts, according to the

distance, and cause each of these parts to use a different elevation at the same time, and against the same object. For instance, suppose one part to use the elevation of 900 yards, and the other to use that of 1000 yards. The beaten zone for the first will extend from 850 to 950 yards; the beaten zone of the second, from 950 to 1050 yards. Thus these zones will overlap, and give a zone of 200, instead of 100 yards in depth. The greater the range, the greater the error of estimation, and consequently the depth of ground to be covered.

We are thus enabled to attain our first object; but we have sacrificed our second, for the bullets being spread over so much more ground the intensity of the fire is correspondingly reduced. To gain both our ends, we must increase the expenditure of ammunition in like proportion, by increasing the number of firers, or the number of rounds for each.

Number of Sights.—The number of sights to be used depends on several considerations :

1st. On the probable error. If the range is known, only one sight should be used at any range. If it is found with instruments, the number of sights depends on the percentage of error for the instrument and the user. If it is merely estimated by the eye, the number depends on the training of the men. In every case, the number used should be as small as possible, for the efficacy of the fire is inversely proportional to the extent of ground over which the bullets spread.

2d. On the facilities for observing the strike of the bullets. This is really a part of the first, as it is a means of correcting

erroneous estimates of distance. When the ground is favorable, the dust thrown up by the bullets of a volley may be observed, and this will at once show the practiced observer whether the elevation is too great or too little, though not how much.

3d. On the nature of the objective. If this be one of considerable depth, as may sometimes occur, its depth will tend to compensate for the insufficient depth of the beaten zone, because it makes no difference what part of it we hit, (as for example, whether we hit the head or the rear of a column,) so long as we hit some part. A greater number of elevations must be used against a moving object, without depth, which is constantly altering its distance, than against a stationary object.

4th. On the nature of the slope of the ground on which the bullets fall by which the depth of the beaten zone is increased or decreased. Probably the officers who direct the fire will very seldom be able to know such slopes with much accuracy, but a clear understanding of the kind of influence they will exert will be of value, as throwing light on the problem of how many sights to use. The subject will be more properly discussed in another place.

Rule.—To deduce a rule for finding the number of sights. The total depth of the beaten zone must be twice the error. The difference between sights cannot be greater than 100 yards. Subtract from the error 50 yards, and this will give the difference between the supposed range and the sight next to it on

her side. Thus suppose the error is 100 yards; 100—50—
50, and we use two sights, one 50 yards less and one 50 yards
greater than the estimated range. Suppose the error is 150
yards; 150—50—100, and we use three sights, one for the
range, one 100 yards less, and one 100 yards greater. If the
error be 75 yards, then 75—50—25, and we use two sights, one
50 yards less and one 25 yards greater than the estimated
range.

In practice, however, it is usual, with two elevations, to
make one 50 yards less and the other 50 yards greater than the
estimated range; and with three elevations, to make one for
the range, one 100 yards less and one 100 yards greater."

In all cases every means should be employed to gain a more
accurate knowledge of the range, and thus to reduce the num-
ber of elevations to be used.

German Rule.—The German regulations of 1887 say that
When a range is guessed and a stationary object is fired at,
one elevation, differing by 50 metres, will be used for ranges
between 400 and 600 metres; two elevations, differing by 100
metres, for ranges between 600 and 800 metres; and three
sights for ranges over 800 metres. If the object be moving,
then for ranges over 400 metres several sights, differing, in the
direction of the movement, by 100 metres, will be used."

French.—The French regulations say: "The simultaneous
employment of several sights against a single object increases
the depth of the ground beaten, to the detriment of the density
of the fire, and therefore this method of procedure must be used

with great discernment. The fire with a single elevation for the distance of the object will always have the greatest efficacy. Two sights, differing by 100 yards, may be used against a moving object or against one of considerable depth."

Austrian.—The Austrians say that the combined use of different sights is to be very exceptional, from the loss which it entails in the density of the fire. •

Italian.—The Italians say that only one elevation should be used under 500 metres; if the distance is known and the object stationary, use one sight up to 800 metres, and two beyond that distance; if the distance is unknown and the object moving, use two sights up to 800 metres, and three beyond that distance.

Manner of Using.—The Germans divide the space which extends between any two hostile forces into three zones :

(1) The short zone, comprising distances up to 400 metres (440 yards).

(2) The medium zone, comprising distances between 400 and 700 metres (770 yards).

(3) The long zone, comprising distances from 700 to 1200 metres (1320 yards).

Except under unusually favorable circumstances, they employ one elevation in the short zone, two in the medium, and three in the long. In order to get the same results, as the range increases, the amount of ammunition must also be increased, even when one elevation only is used. With two or three elevations, if the result obtained is to be the same, two or three times as many rounds must be fired as with only one.

Number Firing.—Therefore the Germans insist that two sights shall not be used unless the body firing be at least a "zug," equal to 70 or 80 men, and the Italians that two sights shall not be used by less than a section of 50 or 60 men; while both insist that at least a company of 200 to 250 men should be employed when three sights are used.

In Germany when two sights are used, each rank uses one, and when three sights are used they are divided among the three "zuges" of the company. In our service, if two sights are used by a company of about 100 men, each platoon should use one. Three sights should not be used by a less body than three companies, and all men of each company would then use the same sight.

Results.—Major Mayne says (apparently giving the result of experiment), that combined sights used according to these rules are found to give an effective result of 10 per cent. of the shots fired, against an object anywhere within the beaten zone, at all ranges up to 1300 yards, provided proper strength be given to the firing body.

Adverse Opinion.—Von Boguslawski and Campe are opposed to the use of combined sights. The latter says: "All tricks of fire are opposed to sound tactics. Long-range fire with combined sights . . . only leads, in the open field, to waste of ammunition. These methods may, however, be advantageously used in siege warfare."

Paquié says (Feux de Guerre): "Fire with one elevation will meet with sufficient density a central zone of 100 to 150 metres

in depth, and the problem consists in bringing the target within this zone. If two elevations be simultaneously employed, differing by 100 metres, the nuclei overlap, it is true, but it is evident that fire loses in density what it gains in depth, unless double the quantity of ammunition be expended. The simultaneous use of several elevations is advisable only when each nucleus has its distinct object—that, is, against an objective of great depth; unless, indeed, it be intended to adopt as a principle the dispersion of hits, and consequent waste of ammunition. If it be further observed that deep formations ought to be destroyed by artillery before they come within the range of the rifle, it will clearly appear that this method will rarely find proper application on the battle-field.”

The question cannot, therefore, be considered settled; but it is constantly to be borne in mind that the object of combined sights is not the maximum of efficacy, but the maximum of certainty; in other words, we should not use them at all if the range could be found within 50 yards, but when it cannot be so found the use of combined sights will give us a small but certain result, instead of the chance of a much larger result coupled with the chance of none at all. Every soldier must desire to see the army to which he belongs so well provided with range-finding instruments, so apt in their use, and so thoroughly trained in the estimation of distances, that the use of combined sights will be always unnecessary.

Rule for Using Combined Sights.—If we assume as correct our statement that the judging of distances may be taught

as to reduce the error to 0.10, the rules for the use of combined sights would be as follows : (for distances estimated),

Up to 500 yards use one elevation for the range.

From 500 to 1000 yards use two elevations, one 50 yards less, the other 50 yards more than the supposed distance.

Beyond 1000 yards, use three elevations, one for the supposed range, one 100 yards less, and the third 100 yards more than the supposed range.

Avoid the necessity for using combined elevations as far as possible, by using every available means to get the range within 50 yards.

The French regulations say: "A collective fire may be opened:

"At 550 yards on a line of skirmishers of slight density (one man to every 5 yards).

"At 660 yards on a line of skirmishers of average density (two men to every 5 yards).

"At 880 yards on a thick line of skirmishers, or on a company with open files."

CHAPTER 6.—THE EFFECTS OF COLLECTIVE FIRING.

The objects of controlled fire may be stated as :

- 1st. To increase the effect of the fire ; and
- 2d. To regulate and economize the expenditure of ammunition.

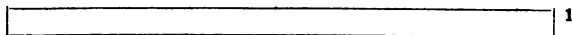
Experiments in Collective Fire.

To discuss these, we must inquire into the phenomena of controlled fire. This subject, judging from our Firing Regulations, has been entirely neglected in this country. It has been studied to a considerable extent in Europe ; “but as the experimental firing has not been in all cases executed under identical conditions, there is not, in appearance at least, a perfect agreement in the results obtained. On the other hand, different methods having been used to register the results, the tables of results are not always easily comparable. Thus it is necessary to state the conditions under which any experimental firing has been executed for determining the destructive effects of collective firing, and also the methods employed for drawing up numerical and graphical tables, for expressing the results of this fire.” It is only after having studied these preliminaries that we can profitably consider the general observations which an examination of these tables has suggested, the technical interpretation of the results which they contain, and

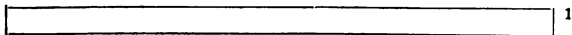
the use made of them in improving the methods of employing infantry fire.

Targets.—As regards the objectives we should choose to fire against in experiments, a French writer says: "When large objects are mentioned, such formations will be meant as may be expected to be seen within 2500 yards, such as a company column (of at least 200 men), a battery of artillery in action, or a squadron. Of course by accident, a column of route, or a battalion quarter-column, &c., may offer itself as an objective; but this will be an exceptional case, and it would not be wise to build any theories on so narrow a basis."

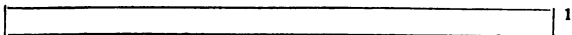
The strength of a company on the Continent of Europe may, after a few days of marching and hard work, be taken as about 200 men. The German and Belgian companies are divided into three sections of about 70 men each, or 35 files, and the rectangle occupied by the company column in close order is about 23 yards wide by 11 yards deep.



4



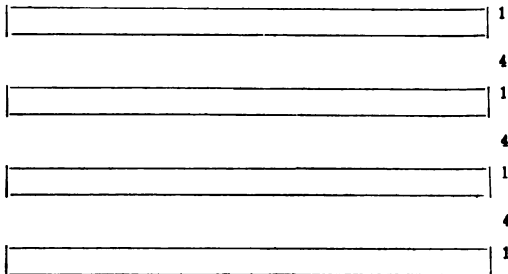
4



1

The French, Austrian, Italian and Russian companies are divided into four sections of about 50 men each, or 25 files,

and the rectangle occupied by the company column in close order is 17 yards wide by 16 yards deep.



The English company of 100 men is divided into two half-companies of two sections each.

The Effects of Collective Firing.

Methods of Recording.—There are two methods by which the effects of an experimental collective fire may be recorded:

1. If a smooth, sandy flat of sufficient extent is available, the points of impact of the bullets on the ground can be recorded by marking out the ground in suitable squares and plotting to scale. A line of targets is necessary for aiming at. In this manner a representation of the horizontal grouping of the hits is obtained. This method has been largely used in France, and to some extent in England in the few experiments there made in collective firing.

From the graphical representation of the horizontal grouping, the hits on any objective may be determined. Draw to scale a rectangle whose length is equal to the front of the objective, and whose depth is equal to the depth of the objective increased by the theoretical dangerous zone for the range and objective. The number of hits in this area gives the hits on the objective.

If the objective be a single line, the depth of the rectangle will be that of the dangerous zone. If the fire is directed on an open column, and if the distance between the successive parts of the column is greater than the dangerous zone, each section must be treated as a single line.

2. Any level ~~part~~ of ground of sufficient extent, parallel to the line of sight, may be chosen, and a series of vertical targets erected on it, at any convenient distance apart. These are usually placed 10 yards or 10 metres apart, but the Germans place each target so far behind the one in front that a bullet grazing the top of the latter would strike the foot of the former. In this case each bullet *theoretically* leaves but one mark on the whole series of targets.

From this vertical record and the theoretical dangerous zone



FIG. 10.

the horizontal representation is easily deduced, and also the number of hits that would have been made on a series of targets placed 10 metres apart. Each target would be hit by all the bullets falling in rear of it at a distance equal to the theoretical dangerous zone for the target and range.

German Experiments and Tables.—The Germans, using this method, obtained the results embodied in tables A, B, C, and D. The terms of these series were obtained by a very large expenditure of ammunition, and the series as stated for the number of rounds given were found by proportion; hence the firing of only 100 rounds may not give exactly the results of the tables, but the approximation will become closer as the number of rounds is increased. The length of the series will not vary much, provided a sufficient number of shots be fired to show clearly the grouping of the hits. Fifty shots is the minimum for this purpose.

The data in these tables can be represented by graphical curves, and the anomalies thus eliminated; but the Germans seem to prefer leaving these anomalies just as they occur.

The number of hits in any series exceeds the number of shots fired, because the same bullet may traverse several screens. The length of a series represents the depth of the beaten ground, and we see that the shorter the range the greater this is.

Although for convenience the center of impact has been placed at the theoretical distance for the elevation, it was found in reality that up to 700 metres it was at a distance in front of this target equal to half the depth of the theoretical dangerous

zone. This was due to the fact that aim was taken at the foot of the first target of the series. Beyond 700 metres, the center of impact coincides practically with the object fired at.

Definition.—The term “effective dangerous ground” has been applied to that portion of the beaten ground contained between the first and last screens which receive 10 hits.* Up to 800 metres an effective dangerous ground of 100 metres is obtained by firing 100 rounds; as the range increases the number of rounds which must be fired to get this depth also increases, so that at 1000 metres we must fire 200 rounds, and beyond 1200 metres 300 rounds, to get a continuous effective dangerous ground of 100 metres.

If the error in judging the distance exceed half the depth of the effective dangerous ground, only a few scattered shots will hit the particular mark aimed at, if only one elevation be used. In such a case, as has already been said, the nucleus may be brought to fall on the object by increasing the number of elevations, and thus the depth of the effective dangerous ground.

Deductions from Tables.—Referring to Table C, we see that the effective dangerous ground, with, for instance, the sights for 600 and 700 metres, firing 100 rounds with each sight, extends from 510 to 770 metres, a depth of 260 metres. But if we fire 200 rounds with the single elevation of 600 metres, the depth of this ground is only 180 metres.

With the three sights of 1100, 1200 and 1300 metres, we get

* On the supposition that 10 of peace results may be expected in war.

the effective dangerous ground shown in Table XI; that is, firing 100 rounds at each range, 140 metres,* and firing 200 rounds, 310 metres. "As a rule, it has been found that, when firing 100 rounds, the mean of the number of hits on the screens, when two sights are used, does not vary much from the number made when only one sight is used, and sometimes even exceeds it, while with a combination of elevations the depth of the effective dangerous ground is doubled or trebled." This is a strong argument in favor of combined sights when the ranges are not known within 50 yards.

Stationary Object.—Major Mayne gives a table showing the results of fire at a stationary standing line of infantry, the

TABLE V.

RANGE IN METERS.	NUMBER OF ELEVATIONS.	PER CENT. OF HITS.					
		Range known.		Over-estimated.		Under-estimated.	
		Mayne.	Deducted.	Mayne.	Deducted.	Mayne.	Deducted.
650	{ 1	43.0	43.5	3.0	3.0	3.5	8.5
	{ 2	19.0	19.5	7.5	7.5	14.0	14.0
1050	{ 1	22.5	22.5	1.0	1.5	1.5	1.5
	{ 2	16.5	10.0	4.0	5.5	12.5	4.5

* Considering only the *continuous* dangerous zone.

true distance being 650 and 1050 metres, first over-estimated and then under-estimated, each time by 100 metres. The figures as given in the edition of 1889 do not agree with those which may easily be deduced from Table A, but would seem from the context to be the result of experiment. Table V shows both.

Whichever be correct, an inspection of the table will show that, 1st, when the distance is known, there is a loss of efficiency from using two elevations, as might be expected.

2d, when the range is either over- or under-estimated, the

TABLE VI.

DISTANCES.		ELEVATIONS.	ONE SIGHT. Percent.	TWO ELEVATIONS.		
True.	Supposed.			Per cent. shorter.	Per cent. longer.	Per cent. combined
700	800	800 750 and 850	3.0	14.0	0	7.0
650	750	750 700 and 800	3.0	15.0	0	7.5
600	700	700 650 and 750	3.0	20.0	0	10.0
550	650	650 600 and 700	3.5	25.0	0	12.5
Average.....			3.125	.....	.....	9.25

use of two elevations gives from two to four times as many hits as one elevation gives.

Moving Object.—The case of moving objects is somewhat more difficult. Suppose an enemy to leave cover at 750 metres and to advance to 550 metres, and that during this movement four volleys are fired on him at the distances of 700, 650, 600, and 550 metres.

Case 1: ranges known. The best results will, of course, be obtained by using one elevation.

Case 2: ranges over-estimated 100 metres. The results from using one and two elevations at each of the supposed distances are shown in Table VI.

That is, with one sight for each of the over-estimated ranges, we get an average percentage of 3.1; with two sights for each of the supposed ranges, we get an average percentage of 9.25—nearly three times as much.

Case 3: Ranges under-estimated. The results are shown in Table VII.

That is, using one sight for each of the supposed ranges, we get an average percentage of 8.6, and using two sights for each, we get an average of 14.9; nearly twice as much.

A greater percentage might be made in both cases, by using either one or two elevations entirely different from the supposed ranges. Thus, by using the 600 yards range throughout, the percentage would be 26.0; but this would scarcely be done. It would imply using a range less than any of those estimated, when the range is over-estimated, and the longest of those es-

TABLE VII.

DISTANCES.		ELEVATIONS USED.	ONE SIGHT. Per cent.	TWO SIGHTS.		
True.	Sup- posed.			Per cent. shorter.	Per cent. longer.	Per cent. combined
700	600	600 550 and 650	3.0	3.0	26.5	14.75
650	550	550 500 and 600	8.5	4.0	24.0	14.0
600	500	500 450 and 550	14.0	4.5	25.5	15.0
550	450	450 400 and 500	9.0	5.0	27.0	16.0
Average.....			8.625	.....	.....	14.88

timated, when it was under-estimated; which is an absurdity, for a man who knows whether a range is over- or under-estimated knows enough to correct his error.

We may say, then, that in all these cases, when the range is estimated, with the accompanying probability of error, the use of two elevations gives better results than the use only of the elevation for the supposed distance, and that, while other methods may give greater results (with especially good luck), they are more likely, in the general case, to give none of any value.

Variations.—The figures in these tables are deduced from firing executed under very favorable conditions; by skillful men,

firing with rests. They could hardly be realized under ordinary conditions, even in peace experiments, being liable to change from many causes.

The density and regularity of the series vary with the character of the rifle. Increase in the accuracy of the rifle increases the density of the hits on the center of impact and on the adjoining screens, and gives representative series of greater regularity in the increase and decrease of the terms.

The flatter the trajectory, the more hits there will be on each screen, and the longer the whole series. The greater the uniformity of manufacture, the less the length of the series.

Test of Rifles by Collective Firing.—It is not sufficient to study the causes of dispersion separately. A rifle, A, may give shorter beaten zones than a rifle, B; but B may have a flatter trajectory than A. Then the density for A will be greater than that for B, and the depth of the dangerous zone greater for B than for A; and the relative destructive effect, which is the product of these two,* may or may not be greater for B than for A. Thus suppose we have

A, density 4 per square yard. Dangerous zone, 6 yards.
Destructive effect, 24.

*For the rectangle for A, in which an object of one yard front may be struck, has a depth of 6 yards and area of 6 square yards; number of bullets which may hit, 6×4 , or 24.

Same rectangle for B has depth 9 yards, area 9 square yards; number of bullets which may hit, 9×3 , or 27.

B, density 3 per square yard. Dangerous zone, 9 yards.
Destructive effect, 27.

This shows that, in estimating the value of rifles, it is not enough to compare simply their accuracy and flatness of trajectory. We must also compare the spread of the bullets when twenty or more of each kind are used together in collective firing. That rifle which then gives the greatest regularity and density, coupled with the other qualities already discussed, will be the best. There is no method more searching for testing the value of rifles than the comparison of the series obtained with them in long-continued collective firing.

Importance of Training.—If the firers be less skillful, the series will be both less regular and less dense. As their skill goes on decreasing, the irregularities will be accentuated, and gaps will appear, especially near the distance corresponding to the elevation used.*

This shows that the instruction and training of the soldier is as important, and has as much influence, in collective as in individual firing. It also shows that the fire of several men at a single target, at distances over 400 yards, is not the true gauge of their efficiency. They should fire at a series of screens, of sufficient depth to register all the hits; then, from the density and regularity of the grouping, an estimate can be formed of the value of their fire. The position of the center of impact is

*The same is true when the firing is without rests; for which reason the Germans insist on the necessity for firing over rests at long ranges.

no clue, for it does not depend on the efforts of the men on factors beyond their control; and, in fact, the centre of impact does not usually coincide with the engraved range corresponding to the elevation used. For instance, a fall of temperature below that for which the sight is graduated tends to bring it towards the firing point, and a rise of temperature carries it further away.

If fewer rounds are fired than those given in the table irregularities are accentuated, and the effective danger zone diminished in length. This is shown in Table VIII, the series for 600 metres when 100, 50, 25 and 10 rounds are fired against a line of standing men.

Table IX, taken from the German Firing Regulations, indicates the relative vulnerability of infantry in different positions and positions.

The results of the French experiments of 1876 are given by Captain Bazin as in Table X. The distances were measured and the figures indicate the best results that could be obtained under that supposition.

The French experiments made at the camp of Chalons in 1879, over measured ranges, gave the results in Table XI.

	670	680	690	700	710	720	730	740	750	760
	16	11	5	3	*	1	2	2	2	1
	8	5	2	1	*	*	1	1	1	*
	4	2	1	1	*	*	*	*	*	*
	1	1	*	*	*	*	*	*	*	*

n. ny	NUMBER OF BULLETS FIRED.	NUMBER HIT OUT OF 50 UPRIGHT MEN EXTENDED AT EQUAL IN- TERVALS OVER A FRONT OF 110 YARDS.
10	200	35 to 41
0	200	25 to 38
0	200	25 to 38
5	200	20 to 35
9	200	12 to 23
8	300	20 to 35
5	300	15 to 35
5	200	15 to 28
4	300	12 to 25
8	*	*
8	*	*

OF ROUTE OR OF MARCHING TO A
FLANK IN FOURS.

DISTANCES.						r — nn. —
		Half-section.	Section.	Half-com- pany.	Company.	
Metres.	P	Per ct.	Per ct.	Per ct.	Per ct.	.0
500	2	13.3	15.0	17.8	24.0	.6
600	2	9.1	10.2	13.2	18.3	.5
700	2	6.0	7.1	10.0	14.3	.0
800	1	3.8	4.3	7.2	11.2	.8
900	1	2.0	3.1	5.8	9.2	.3
1000		1.4	2.2	5.0	8.0	.2
1100		1.0	2.1	4.2	7.1	4
1200		0.4	2.0	4.0	6.2	8
1300		0.3	1.9	3.9	6.0	— ay
1400		0.2	1.7	3.1	5.2	
1500		0.1	1.6	2.4	4.4	
1600		*	1.5	2.2	4.0	for
1700		*	1.4	2.0	3.8	
1800		*	1.0	1.8	3.0	

TABLE 1

n.	1950-1951					1952-1953
	1	2	3	4	5	
my	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001
10	0.001	0.001	0.001	0.001	0.001	0.001
0	0.001	0.001	0.001	0.001	0.001	0.001
0	0.001	0.001	0.001	0.001	0.001	0.001
5	0.001	0.001	0.001	0.001	0.001	0.001
9	0.001	0.001	0.001	0.001	0.001	0.001
8	0.001	0.001	0.001	0.001	0.001	0.001
5	0.001	0.001	0.001	0.001	0.001	0.001
5	0.001	0.001	0.001	0.001	0.001	0.001
4	0.001	0.001	0.001	0.001	0.001	0.001
8	0.001	0.001	0.001	0.001	0.001	0.001
8	0.001	0.001	0.001	0.001	0.001	0.001

TABLE XI.

DISTANCES.	UPRIGHT POSITION.		KNEELING POSITION.		LYING-DOWN POSITION.	
	Line.	Column.	Line.	Column.	Line.	Column.
Metres.						
1000	20.0	33.0	12.5	25.0	6.2	20.0
1100	14.2	25.0	9.0	20.0	4.5	16.6
1200	11.0	20.0	7.1	16.6	3.5	12.5
1300	8.3	16.0	5.2	12.5	2.6	9.0
1400	6.6	12.5	4.1	10.0	2.0	5.8
1500	5.2	10.0	3.3	8.3	1.7	4.3
1600	4.1	7.6	2.5	6.2	1.2	3.2
1700	3.2	6.2	2.0	4.7	1.0	2.4
1800	2.7	5.0	1.6	4.0	0.8	1.8

Expression for Vulnerability.—There is still another way of finding the vulnerability of a formation. Let

N be the total number of hits,

A the area over which they fall, in square yards,

Z the depth, in yards, of the theoretical dangerous zone for the range and target,

D the depth of the formation, and

L its length, both in yards.

n.	NUMBER OF BULLETS FIRED.	NUMBER HIT OUT OF 50 UPRIGHT MEN EXTENDED AT EQUAL IN- TERVALS OVER A FRONT OF 110 YARDS.
ny		
0	200	35 to 41
0	200	25 to 38
0	200	25 to 38
5	200	20 to 35
9	200	12 to 23
8	300	20 to 35
5	300	15 to 35
5	300	15 to 28
4	300	12 to 25
8	*	*
8	*	*

OF ROUTE OR OF MARCHING TO A
FLANK IN FOURS.

DISTANCES.				
	Half-section.	Section.	Half-company.	Company.
Metres.	Per ct.	Per ct.	Per ct.	Per ct.
500	13.3	15.0	17.8	24.0
600	9.1	10.2	13.2	18.3
700	6.0	7.1	10.0	14.3
800	3.8	4.3	7.2	11.2
900	2.0	3.1	5.8	9.2
1000	1.4	2.2	5.0	8.0
1100	1.0	2.1	4.2	7.1
1200	0.4	2.0	4.0	6.2
1300	0.3	1.9	3.9	6.0
1400	0.2	1.7	3.1	5.2
1500	0.1	1.6	2.4	4.4
1600	*	1.5	2.2	4.0
1700	*	1.4	2.0	3.8
1800	*	1.0	1.8	3.0

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for

yards or 9 metres in depth, and the range 1200 metres, ought to be $\frac{15+9}{2}$, or 12 per cent. With the same object at 900 metres range, the hits ought to be $\frac{39+9}{3}$ or 14 per cent.

The comparison between the calculated percentages and found by experiment is shown in Table XII, the object being a line of standing infantry, 5 feet 8 inches in height.

An examination of these tables shows very considerable crepancies.* Thus, the percentage of hits on a standing company column, standing, at 600 metres, is given as "25 to 50," "18.0" and "52." on a company column, standing, at 800 metres, as "20" "14.3" and "41.5"; on a line lying down at 1100 metres, as "1 to 6," and "6.2"; and on a company column lying down at 1100 metres, as "6 to 15" and "20.0."

The Belgians' experiments give much the smallest percentages, and would seem to be most trustworthy, both on account and from the coincidence observable between the results as given by calculation and by experiment.

Shallow Formations.—All these tables agree in showing a great advantage, as far as vulnerability is concerned, as opposed to column formations at all ranges. This is expected from the fact that the depth of the nucleus is greater than its width. This difference is not so marked at shorter ranges (700 metres or less); a fact which may have an important bearing on the question of attack formations.

* See Table XIII, attached.

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30

31

32

33

34

35

36

37

38

1140	115
15	11
2	2
...	...
17	13

1130	114
24	30
2	4
...	...
26	34

0801 0701 0601

0501

0401

0301

0201

0101

1310	1320	1330	1340	1350	1360	1370	.....
...
1	...	...	...	...	...	...	...
7	10	8	6	3	...	...	...
8	10	8	6	3	...	...	...

1300	1310	1320	1330	1340	1350	1360	1370
...
2	2	...	...	...	...	...	...
28	14	20	16	12	6	4	...
30	16	20	16	12	6	4	...

Limiting Range.—Both French and Germans agree that not more than 10 per cent. of peace results can be relied on in war, and the French say that there is a waste of ammunition unless a loss of 10 per cent. in peace (1 per cent. in war) can be inflicted. Applying this last observation to the Belgian figures, we see that, if the range be known, a company column, standing, may be fired on up to 1400 metres, but a company in line, standing, only up to 800 metres.

Cavalry.—The height and depth of an object are much more important than its width; hence fire may be opened on cavalry at longer range than on infantry.

Artillery.—In Austria, in 1878, a company of 211 men fired at targets representing three guns in action with their detachments, at 1500 yards, the range being known. Ten rounds were fired by each man in 3.5 minutes; 189 balls or 9 per cent. struck the targets, or, in other words, the guns were silenced in 3.5 minutes, the whole of the 108 men forming the personnel being hit in that time. At 1000 yards they obtained 11.5 per cent. of hits.

In France a company of 250 men firing on a battery of artillery at 1500 yards, the range being known, disposed of all the horses and men in a few minutes.

On another occasion 120 men fired 10 volleys against a battery of 6 guns, placed 12 metres apart, with the limbers 20 metres in rear of the guns, and with targets representing the men and horses. The percentages were as follows:

On men and horses only,

1200 metres	10.5 per cent.
1400 metres.....	8 " "
1600 metres.....	4 " "
1800 metres.....	2.3 " "

On men, horses and material,

1200 metres.....	12 per cent.
1400 metres.....	8.5 " "
1600 metres.....	5.0 " "
1800 metres.....	3.8 " "

These examples show that if the proper elevation for the distance be known, artillery may suffer from infantry fire at 1200 metres (over 1300 yards), and that the limiting range for profitable fire depends on the formation and character of the objective.

Expenditure of Ammunition.—From Table 5 we see that if we fire 200 rounds, at 700 metres, at a standing line of 50 men deployed with equal intervals over a front of 110 metres, 20 to 25 of these will be put out of action. Take the lower as the correct number. Suppose a company of 100 men firing on one of equal strength, deployed at 2 metres per man. For 200 shots, (1 each,) 20 of the enemy are hit; to hit 100 will require 1000 shots or 5 each for the firers. But this supposes them to be in the open. If they are behind cover many more shots must be fired to get the same result, and if they are lying down, behind cover, and themselves firing with effect, twenty

times the amount stated, or 100 rounds each, would hardly be sufficient for that purpose.

Vulnerability of Groups.—There are no careful and complete experiments to show the relative vulnerability of men, deployed at equal intervals, and in small groups. General Brailmont said that “from 600 to 1200 metres, the chance of hitting a deployed squad of 14 men (8 metres front) or a company in two ranks (48 metres) was the same.” Incomplete experiments to test this, indicated that it was not correct. Targets were used, representing a half-section (12 metres), a section (24 metres), two sections (48 metres) and a company (72 metres). The vulnerability was the same at 400 metres, but as the range increased, the smaller the target the less it suffered. At 1000 metres the vulnerability decreased with decrease of front, as shown below:

Front.....	72 m.	48 m.	24 m.	12 m.
Vulnerability,	1.0	0.97	0.84	0.6

If we suppose the vulnerability to go on decreasing in the same proportion,* that for a front of 5 metres would be about 0.33; that is, the vulnerability in line is to that of the group of 8 men, about as 3 to 1.

Compare this with the results from table on page 102. It will be seen that the relations are nearly the same.

* A safe supposition, since it is really decreasing more rapidly than the range increases.

RANGE.	PERCENTAGE OF HITS.		
	Company 120 men.	Squad 15 men.	Relation.
500	65	36	1.8 to 1
600	49	27	1.8 to 1
700	42	22	1.9 to 1
800	33	15	2.2 to 1
900	25.3	11.5	2.2 to 1

The Germans found that the relation between the number of hits, on a closed company with a front of 110 yards, and on a line of 50 skirmishers with the same front, was about as follows: *

<i>Range.</i>	<i>Relation.†</i>
500	2.5 to 1
600	2.2 to 1
700	2.0 to 1
800	2.0 to 1
900	1.3 to 1

* To be on the safe side we have supposed the percentage of hits to represent the men hit, *i. e.*, only one hit on any target.

† Taking the means in the table.

That is, the relation of vulnerability might be thus stated:

Company to line of groups..... 3 to 1

Company to line extended.....2.5 to 1

Line of groups to line extended, nearly.....1 to 1

Now to calculate the losses by other means. Suppose 50 men deployed at equal intervals on a front of 110 yards. Then suppose the same front occupied by 50 men in groups of 8 men.*

Suppose 100 firers to fire 5 shots at each, at various distances. The 250 shots which form the nucleus fall on an area 110 by 100, or 11,000 square yards. We have the formula, (D being 0):

$$V = \frac{N}{A} + L \times Z;$$

in which N=250, A=11,000, and Z has a different value for each range. If we deduce the values of V from this formula by taking first groups and then single men and summing them for the whole line, they will compare as follows:

<i>Range.</i>	<i>Groups.</i>	<i>Extended.</i>
500	12.3	13.3
600	7.5	7.0
700	3.9	3.6
800	8.1	3.3
900	2.6	2.5

* Flank groups, 9 men each.

This comparison is made on the assumption that the nucleus does fall on the objective, that the latter is in full view, and that the firers aim deliberately. Any failure of these conditions would be slightly to the advantage to the line of groups.

No extended reports have been published of experiments on this subject. Those made abroad are not made public property by the experimenters. (See Appendix.)

All this would certainly seem to indicate that the formation in small groups may be retained without excessive loss up to perhaps 500 yards, thus avoiding the acknowledged evils of early individual deployment, which have been tolerated only because they were considered inevitable. At that range, in a serious attack, the junction of the supports and the reserves will have converted the original thin firing-line into a closed one, so that the question of deployment is then no longer important.

Control of fire therefore enables us to increase the efficacy—

1st. By concentrating it, instead of trusting to the possibility that concentration may be effected by the accidental aiming of a number of men at the same object.

2d. By selecting the most suitable objects, that is the most dangerous and most vulnerable, instead of leaving it to the unguided choice of the firer, and by changing the aim from one object to another when this becomes advisable.

3d. By using the best obtainable information as to the range, either from measurement or the estimates of the most skillful observers; and

4th. By using such a combination of elevations as will insure the falling of some part of the effective dangerous ground on the objective.

It has already been pointed out that this gives not the greatest result, but the greatest certainty of some result.

It enables us to regulate and economize the expenditure of ammunition :

1st. By showing the limiting distance for profitable fire and the quantity needed to obtain a satisfactory result and enabling us to restrain or cease the firing, when range or objective fail or cease to be suitable.

2d. By enabling us to cease firing when the enemy, as will often happen, is concealed by the undulations of the ground.

Suppose a company only 100 strong (and it may be said in passing, that there are many circumstances which go to favor the retention of the small company in our army) deployed on a front of only 100 yards. Now commence individual firing at the rate of some 10 shots per minute, a rate which would probably be exceeded, and the "cease firing" would be a matter of great difficulty, if not an impossibility; while the effect of the fire would be such as we have already found. With troops imperfectly trained, such as our wars must be fought with, the waste of ammunition will be enormous, unless we find the means of checking it in control of fire.

CHAPTER 7.—INFLUENCE OF GROUND.

Thus far we have considered the ground to be sensibly parallel to the line of sight. We must now proceed to consider the effects produced when the ground on which the bullets fall is inclined to that line.

Definitions.—By “rising ground” and “falling ground” we mean ground at the point where the bullets fall—rising or falling, in the direction of the fire, with respect to the line of sight. Unless otherwise stated, it is supposed to extend throughout the dangerous zone. Rising ground is visible and falling ground invisible to the firers. In Fig. 11, C E and D C are rising ground with respect to the ground at A B, but for

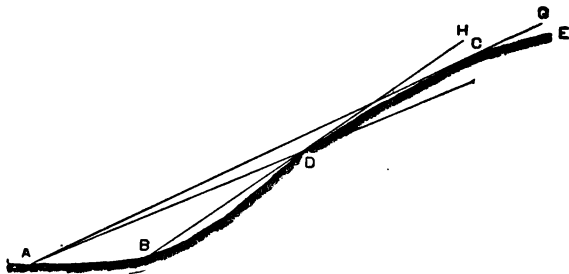


FIG. 11.

our definition they are falling ground because they fall with respect to the lines of sight A C and B D; while D C is rising ground both with regard to the ground A B and the line of sight A D.

The "apparent crest" of such ground is the point where the line of sight touches the ground. Hence the position of the apparent crest depends on that of the origin of fire. Thus, C is the apparent crest for an observer at A, and D is the apparent crest for one at B.

A grazing fire is one in which the bullets pass over the ground at a height less than that of the objective.

The depth of the dangerous zone for any range depends — 1st, on the flatness of the trajectory; 2d, on the height of the object; and 3d, on the shape of the ground on which it stands.

The surface of reception is the portion of the ground on which the bullets fall.

The depth of ground that any obstacle (natural or artificial) shelters from bullets fired at any distance, is the defiladed zone. It is the space which extends from the foot of the obstacle to the first catch of the bullet which grazes the crest. It depends on the range and the height of the obstacle.

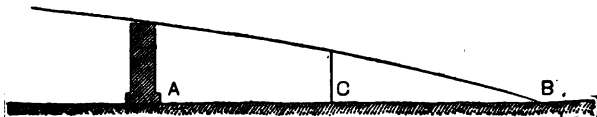


FIG. 12.

The protected zone for any object and obstacle is the difference between the defiladed and the grazed zone. It depends on obstacle, object, and range.

If the height of obstacle be less than of the object, the protection afforded is only partial. Whether complete or partial, the protection afforded by obstacles will considerably diminish the efficacy of fire.

Suppose the surface of reception, instead of being parallel to the line of sight, be inclined to it.

It may be seen from Fig. 13 that the depth of the dangerous spaces will depend on the kind and degree of the inclination.

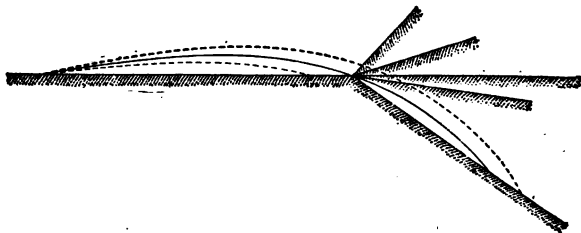


FIG. 13.

In general terms it may be said that on rising ground they will be less and on falling ground greater than on ground parallel to the line of sight.

Relations between Slope of Ground and Angle of Fall.
Suppose the fire to be delivered with any elevation, for in-

stance, with that of 400 yards, and the nucleus of the horizontal group to spread over a depth of 100 yards beyond the crest, the superior limit of the group will be determined by the trajectory of 500 yards.

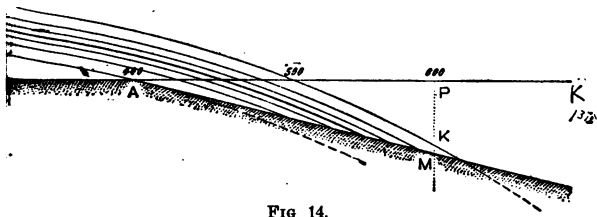


FIG 14.

Draw at A a tangent to the trajectory of 400 yards. It will give the trace of a surface making with the horizontal AB an angle equal to the angle of fall of that trajectory, about $1^{\circ} 1'$.

At 600 yards drop the perpendicular P M. Its value will be given by

$$P M = \tan g. P A M \times 200 = 0.01775 \times 200 = 3.55 \text{ yards.}$$

The 500 yards trajectory cuts this perpendicular at K.

P K is the vertical distance, at 600 yards, between the trajectory of 600 yards and that of 500 yards. Their curvature is slight and the distance so small compared with 600 yards, that there is no sensible error in computing P K as if both trajectories were straight lines.* Fig. 15 shows the proportions of the figure.

*See trajectory, Plate 1.

We have, then,

$P K = \text{tang. (angle of elevation of 600 yards — angle of elevation of 500 yards)} \times 600$; or,*

$$P K = \text{tang. } 18' \times 600 = .00524 \times 600 = 3.14 \text{ yards.}$$

That is, the 500 yards trajectory meets the ground $A M$ some 225 yards in rear of A ; and since the intervening space is all beaten, the beaten zone will have a depth of 225, instead of 100 yards.

A similar calculation, supposing the depth of the nucleus to be 50 yards in rear of A , will give similar results, the further limit being determined by the trajectory of 450 yards, which cuts a perpendicular let fall at 550 yards, at 2.72 yards below the horizontal and 0.06 yard below the ground $A M$; so that



FIG. 15.

* The angles of elevation in these equations are computed by Siacchi's formula, as given in Ordnance Notes (see Table II). These seem more accurate than those computed by Bashforth's tables.

this case, also, the depth of the beaten zone, beyond the crest, is more than doubled when the ground makes an angle with the horizontal equal to the angle of fall of the trajectory which touches the crest.

Angle of Ground Greater.—Suppose, now, the angle $\angle A M$ increased until the line $A M$ forms a chord to the traiec-

$$P M = \text{tang. } 5^\circ \times 200 = 0.08749 \times 200 = 1750 \text{ yards.}$$

$$P K = \text{tang. (angle of elevation } 1200 - \text{angle of elevation}$$

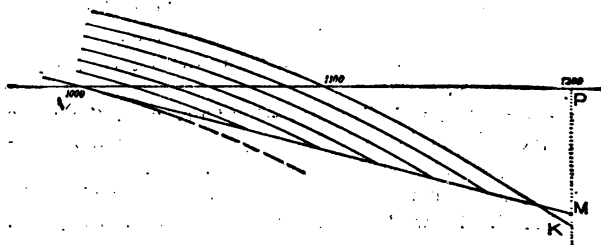


FIG. 17.

$1000) \times 1200 = \text{tang. } (3^\circ 42' 30'' - 2^\circ 52') \times 1200 = \text{tang. } 50' 30'' \times 1200 = 0.01468 \times 1200 = 17.6 \text{ yards; and the dangerous space is doubled.}$

If A M forms a chord of 200 yards from A to M, the slope is about 10 in 100, the depth of the dangerous space is 450 yards, and $F F' = 0.9$ yard, or 2.7 feet.

And so for ranges between: when the angle between the surface of reception and the line of sight is equal to the angle of drop at the crest, the depth of the dangerous space is doubled; when that surface drops as many yards in 100 as there are hundreds of yards in the range the depth of the dangerous zone is five times that on ground parallel to the line of sight.

A further increase in the inclination of the surface of reception tends to decrease the efficacy of the fire, by forming defiladed zones.

The inclination of the surface of reception also has a marked

effect on the ricochets, which are much more effectual when the bullets fall tangentially.

Relation between Slope and Range.—Now suppose the angle between the ground and the line of sight to remain constant, for instance, at 5 in 100, and the range to vary.

The following table will give the effect with sufficient accuracy. The dangerous space will be

- 5 times greater at 500 yards,
- 3.75 times greater at 600 yards,
- 3 times greater at 700 yards,
- 2.5 times greater at 750 yards,
- 2.33 times greater at 800 yards,
- 2 times greater at 900 yards,

than on ground parallel to the line of sight.

In the same way, a slope of 6 in 100 would favor fire beyond 600 yards; one of 7 in 100 fire beyond 700 yards, &c.

Definition.—The normal angle of fall is the angle of fall on horizontal ground. The angle of fall on falling ground is equal to the normal angle of fall minus the angle of inclination of the ground. The angle of fall on rising ground is equal to the normal angle of fall plus the angle of inclination of the ground.

Rising Ground.—On rising ground, therefore, the dangerous space will be diminished in depth; and it will be sufficiently accurate to say that, for ranges up to 1000 yards, the diminu-

tion for rising ground will be in the same proportion as the increase in depth for falling ground.*

Firing Up or Down Hill.—We have considered the line of sight horizontal, and the ground inclined; but the dangerous zones will be affected in the same way for each range, so long as the angle between the two remains the same, no matter what may be the position of the surface of reception in space.

If the surface of reception be horizontal, and falling with respect to the line of sight, we have the case represented in Fig. 18, of a fire directed upwards on the crest of a plateau.

If a horizontal surface of reception be rising with respect to



FIG. 18.

*This is the proportion deduced by Paquie (Feux de Guerre) and used by the Germans. Mayne quotes the latter as saying that, taking the dangerous zones as unity on ground parallel to the line of sight, they are $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ respectively, when the ground rises at an angle of 3° , 5° , and 10° and 2, 3, and 4 when it falls at the same slope.

Though the statement of equality in the proportions is not exact, it is much nearer the truth than the average knowledge of slope and range is likely to be, and therefore sufficient.

the line of sight, we have the case of fire directed from the crest on the plain below.

Relation between Relief and Range.—Suppose the relief of the crest, A, to be in each case 90 feet, or 30 yards. The angles between the line of sight and the ground will be

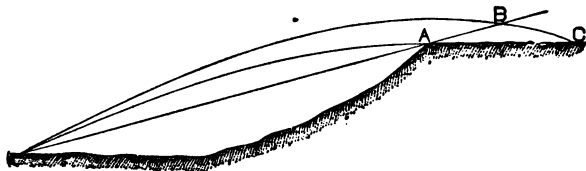


FIG. 19.

numerically equal. If the range is such that the angle of fall becomes equal to BAC , the dangerous space will be in the first case twice as great, and in the second case one-half as great as it would be on ground parallel to the line of sight.

To find such a range: the angle of fall for 700 yards is 1 in 23.6, and at that range the angle between the line of sight and the ground is one in 23.5; the dangerous space in the first case is therefore double that on ground parallel to the line of sight, when the relief is 30 and the range 700 yards. At the range of 650 yards, the trajectory touching the crest rises above the ground to a maximum height of 2 feet, forming a grazed zone, followed by a beaten zone; and since even at the point of greatest elevation a kneeling man would be hit, the dangerous space is four times that on horizontal ground.

As the range continues to decrease, the trajectory just touching the crest grazes the ground beyond, until, when the range becomes less than 550 yards, a defiladed zone begins to be formed.

In the second case, the dangerous ground at the 750 yards range is only one-half that on horizontal ground. At 650 it is diminished in the proportion of 19 to 43. Hence at this range, the dangerous ground in the first case is more than 8 times that in the second case.

Suppose the relief to be 25 yards. The angle between the line of sight and the ground for the 650 yards range is 1 in 26; the angle of fall, one in 26; hence at this range the dangerous space will be about doubled. At 500 yards the defiladed zone begins to be formed.

The same will be true for other elevations and ranges, and the rule for finding the range at which the efficacy of the fire begins to diminish may be thus stated:

$$R = \sqrt{H},$$

in which R is the range in hundreds of yards, and H is the relief in yards.

Thus to sweep the summit of a level plateau:

Having a relief of 16 yds, the range must be at least 400 yds

"	"	"	"	25	"	"	"	"	"	"	"	500	"
"	"	"	"	30	"	"	"	"	"	"	"	550	"
"	"	"	"	36	"	"	"	"	"	"	"	600	"
"	"	"	"	64	"	"	"	"	"	"	"	800	"

and so on.

It is not to be supposed that in order to make use of these principles, the ranges and the slopes of the ground must be known with absolute accuracy. But every officer can remember that the dangerous space will be increased when the surface of reception presents :

For ranges beyond 400 yards, falling slopes up to 4 in 100, or a plateau of 16 yards relief.

For ranges beyond 500 yards, falling slopes up to 5 in 100, or a plateau of 25 yards relief.

For ranges beyond 600 yards, falling slopes up to 6 in 100, or a plateau of 36 yards relief.

For ranges beyond 700 yards, falling slopes up to 7 in 100, or a plateau of 49 yards relief.

For ranges beyond 800 yards, falling slopes up to 8 in 100, or a plateau of 64 yards relief.

For ranges beyond 900 yards, falling slopes up to 9 in 100, or a plateau of 81 yards relief.

For ranges beyond 1000 yards, falling slopes up to 10 in 100, or a plateau of 100 yards relief.

Though the same number of bullets are spread over much more ground under these conditions, the efficacy of the fire is not therefore decreased, on account of the increase of the dangerous zones. For example, the normal angle of fall for 500 yards is about 2.5 in 100. If the slope of the ground be 4 in 100, the real angle of fall will be 1.5 in 100, giving nearly the dangerous zone of 300 yards, all parts of which are efficaciously beaten.

Influence of Ground on Vulnerability.—A vertical object without depth will be equally vulnerable to fire at a given range, without regard to the inclination of the ground. Hence, the results of fire on a line are not modified by the slope. But, it is different with any deep formation.

A battalion in attack formation on falling ground may have all its echelons within the dangerous zone, which on ground parallel to the line of sight will include only the first two, and on rising ground only the first line.

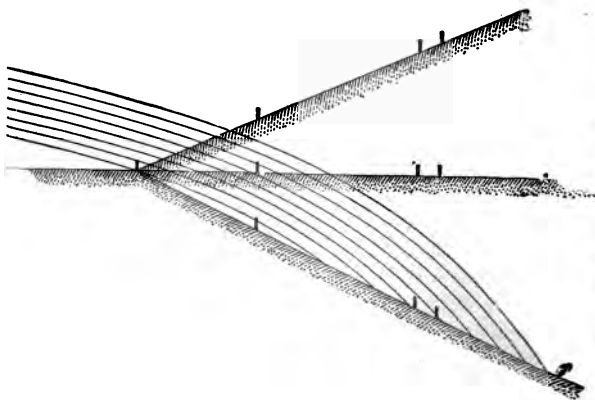


FIG. 20.

Deep Formations.—A deep closed formation of moderate depth, such as a company column of fours with a depth of about 40 yards, will on rising ground be wholly within the dangerous zone; on horizontal ground it will, at 800 yards, have the same vulnerability as a vertical object without depth; but with a height of about 12 feet, and at 1400 yards, the same vulnerability as one with a height of about 20 feet.



FIG. 21.

On falling ground its vulnerability will be decreased, especially if it is within a defiladed zone.

Influence of Ground on Combined Sights.—On rising ground the dangerous zones are narrower; hence, in order to be sure that some part of the nucleus falls on the objective, the number of elevations must be increased. On falling ground, the depth of the dangerous zones is greater, and the number of elevations for the longer ranges may be decreased.

Value of this Knowledge.—Knowledge of the shape of the surface of reception may not be exact, but all officers should know the effects which it produces, and it will often be possible to obtain such knowledge as will enable the value of the fire and the results realized from the expenditure of ammunition to be much increased. An instance of this may be found in bat-

ties where the real attack is to be on the flank while the enemy is detained by a demonstration in front. In such a case it is evident that there is an advantage in pushing the frontal attack only to such distances as will give the greatest effect to fire at comparatively long ranges, by which the desired object is attained with greater ease and certainty and less loss. If it can be determined that the enemy's position is along the crest of a plateau, or from any other configuration of the ground forming "falling ground," a fire may be opened on it from the front, which, without leaving any defiladed zone behind the crest, will sweep the ground for 300 or 400 yards in rear, and will most powerfully divert his attention.*

Comparison of Rising and Falling Ground.—Comparing the two, the French regulations say: "On rising ground the objectives are visible and distinct from each other; they are only indifferently sheltered by the folds of the ground, and an efficacious fire can be directed on each of them."

The effects of ricochets are less than on parallel ground.

In order to obtain the same depth of beaten ground as on parallel ground, the number of elevations must be increased.

Supports and reserves will not generally suffer from fire directed on the first line, and can be hit only by fire directly aimed at them.

*This does not imply that when the real attack is frontal such a policy should be adopted. In such a case the object of battle, the destruction of the enemy, can be attained only by driving him from his position by the most rapid and vigorous advance possible.

On falling ground fire under favorable conditions will render dangerous great spaces in rear of the crest. Fire directed on the first line can hit supports and reserves at distances at which they could be touched on parallel ground only by fire directed on them with the proper elevation.

The fire will be efficacious at greater ranges.

Artillery in position on the crest will soon be in danger from infantry fire.

The dispositions of troops in rear of the crest are not visible.

Collective fire of small width is not the most suitable for the attack of a position of this kind ; width must be given to it in order to sweep the ground in rear of the crest, and strike the troops in reserve.

Ricochets.

An important advantage in firing on an enemy posted on falling ground is the increased value of the ricochets. A ricocheting bullet rises, in general terms, at twice the angle of fall, and on falling ground this angle is diminished, and the effect of the ricochet increased.

On rising ground, on the contrary, the angle of fall is increased, and the ricochet prevented or its value lessened.

On average ground, the limiting angle of fall for ricochets is about 15° , for the rifles and bullets now in use.

.

Manner of Occupying Ground Inclined to the Line of Sight.

The differences in the depth of the dangerous zones and the efficacy of fire due to the shape of the ground have caused radical differences of opinion as to the best method of occupying defensive positions.

Such positions will usually be more or less elevated above the ground over which the assailant must advance, and hence, in general terms, the fire of the attack falls on falling ground and that of defense on rising ground.*

The dangerous zones of the former will therefore be increased, and those of the latter decreased in depth.

A position may be occupied in one of three ways, each having its advocates:

1. The crest may be strongly held.
2. The crest may be lightly held, for the sake of observation, and abandoned at an opportune moment, while the main line of defense is placed from 500 to 800 yards in rear of it.
3. A line in front of the crest may be held by infantry, leaving the crest for artillery, and as a cover for the reserves.

The first may be considered as, up to date, the normal disposition. The advocates of the second method base their arguments on the effect of inclined fire.†

*That is, rising or falling with respect to the line of sight.

† The ablest exponent of this view is Commandant Paquie.

They say that the occupation of the crest hides the troops in rear of it from the enemy's view, but not from his fire.

From the beginning of the preparation of the fight, the echelons of the defender can be enfiladed by the fire directed on the crest, and the battalion and regimental reserves and the troops of the second line will be successively struck by the assailants' fire, which will progressively sweep the rear of the position, up to a limit varying with the relief and the profile of the ground.

The fire of the defender, on the contrary, menaces only the troops on which it is directed; if it is aimed at the first line it does not reach either supports or reserves, and *vice versa*.

When the assailant has carried his firing-line by successive bounds to within 500 metres of the position, the firing-line, supports and reserves of the defense will suffer at the same time from the same fire; the efficacy of this fire will be especially great on the battalion reserves; the supports and reserves, lying on their knees, will be able to find cover during their halts. Fire delivered at 400 metres from the crest ceases to be grazing and leaves a defiladed zone on the plateau, while the bullets, rising to a height of 8 metres, fall 600 metres in rear of the target at which they are aimed. If the rear of the position be on a reverse slope, this distance may rise to 900 metres.

Artillery positions should be beyond the efficacious range of hostile infantry. But the occupation of the crest requires that the artillery, if it does not occupy a part of the line of defense, should at any rate be only a short distance in rear of it. In this position the defender's artillery will find itself exposed to

the fire of infantry. This may not have been true when the range of infantry fire was not more than 300 yards, but it is true with modern arms.

On the other hand, the action of the assailant's artillery will be greatly favored, since it will not be at all exposed to efficacious fire from the crest.

Suppose now, that the line of defense, instead of being at the crest, is 700 or 800 yards in rear on a plateau, or at a similar distance on the reverse slope of a height.

Its exact position will depend on the strong points which may be found there, and in default of such points, it will be strengthened by hasty intrenchments.

We do not abandon completely either the crest or the advantages it offers for reconnoissance and watching the enemy. A good defense cannot consist in awaiting the enemy on a single line; but the defense on the crest itself will not be stubborn. The role of the defenders of this advanced line will be to delay the enemy, to force him to deploy and develop his intentions, and to feign a retreat in order to draw him on to ground where his means of action will be paralyzed. Artillery may be placed for a while on this line, with instructions to retire as soon as it is menaced by infantry fire.

Suppose the enemy master of the crest, and the defender within the principal line of defense, and let us see what are the new conditions of the fight, of which the beginning seems so favorable to the attack. If he advances he finds himself

INFLUENCE OF GROUND.

exposed to the infantry and artillery fire of the defeated under the best conditions possible, over know

The fire of the defenders, directed on the crest, a moment when the first of the attackers make their appearance, will form a beaten zone of considerable extent on the slopes or the lower ground. Through these successive lines of the attack must pass to reinforce the line.

Thus we may contrast on the one side the danger under which the artillery would act, and on the other the assured action of artillery and infantry, under the best conditions.

Again, if the line of resistance in rear of the crest consists of strong points of support, such as houses, walls put in the way of defense, &c., requiring artillery to force them, it is nearly invulnerable that any frontal attack ought to be successful. If these houses, walls, &c., are on the crest, their offensive value is much diminished, because there they are exposed to the artillery of attack.

Defenders who can be reinforced by their support reserves, having before them an extensive field of fire, ranges marked, under cover, either natural or artificial, by their artillery, covered by the ground from the hostile artillery, with full scope for their offensive action against an enemy delayed and shaken by the resistance of the advanced line, have all the elements in their favor which they can well desire.

During the war of 1870-71 some examples are to be found of defending a position in rear of the crest which are said to have been always successful.

At the battle of Champigny the French made a sortie against the German investment lines. The lines of defense at this point were about 400 yards in rear of a crest which commanded it slightly, as the ground sloped gently down from the crest. The German infantry were posted behind crenelated walls, and their artillery behind epaulments. This line was completely hidden from view of the French artillery. The French infantry found no difficulty in dislodging the enemy's detachments from their advanced positions in front of the crest. At the crest the resistance was firmer, but still not serious; the Germans retired, seeking to entice the French after them. These, on arriving at the crest, were subjected to a heavy fire, but they succeeded in obtaining some shelter, and returned the fire, without doing the Germans, who were well sheltered, any serious damage. The French then awaited the arrival of their artillery, which was required to effect a breach in the German defenses, so as to enable them to assault.

As soon, however, as the guns showed themselves, and before they could even come into action, a withering short-range rifle-fire was directed on them, with such effect that all but a few guns were unable to open fire, and these were soon silenced, and the artillery compelled to withdraw. The infantry, which had not been able to resume the advance, was also compelled

to retire. General Ducrot, narrating the action, said: "We were vanquished by the ground."

At the battle of Buzenval the same thing happened. The French ascended the slopes of the plateau, held by the Germans in rear of the crest. The French reached the crest, but could not bring a single gun into action. Their infantry found themselves singly opposed to the combined infantry and artillery of the enemy, covered by walls and epaulments, and consequently could do nothing.

The Duke of Wellington was accustomed, in taking up a defensive position, to seek out a plateau and establish himself behind the crest, just out of view of the enemy. The front slope was defended by skirmishers. The French columns of attack, on arriving at the crest, were disordered and demoralized by a heavy fire of bullets and case-shots from the real line of defense, some 50 yards in rear of the crest, followed by a bayonet charge in line.

It is said that on these principles the front edge of a wood is not the best line for defending it. The advocates of this view consider this edge an excellent advanced line; but the true line of defense, they say, is musketry range in rear of the wood, whence it would be invulnerable to infantry, behind the cover it would utilize, necessitating the use of artillery to force it. Infantry placed at the edge of a wood can effectually oppose the enemy's infantry alone; but when the latter is aided by artillery, the defenders, who cannot be effectually supported by their own artillery, are badly situated.

As an example of this, the French at Spichern held the crest of a steep slope, covered with woods of which they held the lower edge but lightly. The Germans soon got through the woods and to the crest, but could not advance beyond that point, even after the guns had been dragged up, until the French left had been turned and they retired.

Arguments for Holding the Crest.

The advocates of this view, while they acknowledge the theoretical correctness of the statements just given, say that we must in practice guard against drawing from them conclusions too absolute.

Even if the assailants' fire does pass over the crest, the troops and guns on the crest, and the echelons in rear, can protect themselves by masks of earth or other shelters. We have seen how much the question of inclined fire depends on knowledge of the range, of the difference of level, and of the slopes of the ground, none of which data are or can be accurately known in the field.

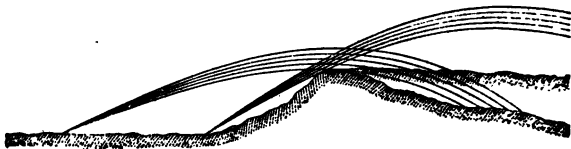


FIG. 22.

A near approach to the crest tends to create on the plateau or reverse slope a defiladed zone, which increases as the range decreases, and permits troops to be concentrated near the crest, or the firing-line to be retired.

Again, as the assailants approach, and their bullets fall further and further to the rear, reinforcements can advance in safety, just when they are needed.

The firing-line of the attack will not change their sights after they come within 400 yards of the crest, and bullets fired at less range will go well over the crest and to the rear.

The modern idea of a good position is one which offers an extensive clear field of fire in front of a series of strong tactical points of support, within supporting distance of each other. These are strongly occupied, while the intervals are lightly held, and the artillery and the reserves to be used in counter attacks are posted in, or in rear of these intervals, where they will not suffer from the fire which the occupied parts draw on themselves.

A good position must give opportunity for counter-attacks, and these are best directed against the flanks of the attack. A position in rear of a lightly occupied crest would cause the enemy to deploy equal strength along his front, since there are no strong points to attract his troops, and hence they would not offer any flanks to the defender's sorties.*

* Nor, on this theory, be able to concentrate his own troops for any effectual attack.

In numerous cases in the war of 1870-71 where a position was held at the crest, there is nothing to show that the fire passing over the crest produced any such effect as has been stated, or that it prevented a vigorous defense, or the bringing up of supports. The French positions were almost invariably carried by being out-flanked and turned, and not by the effect of fire directed on the crest.

The modern method of putting houses, walls, &c., in a state of defense is not to occupy the places themselves at first, but to establish an outer line, covered by obstacles against which artillery has but little effect. The walls and houses would only be occupied after the outer line had been penetrated, and the enemy's artillery compelled to cease firing for fear of hitting their own troops. In this manner, villages and houses on the crest would still form strong points of support; and on the crest they confer the additional advantage of an extensive view over the ground in front.

General Brialmont writes: "Those who quote the battles around Paris and Metz, [in favor of a position in rear of the crest,] forget the difference between the defense of a line of investment and the defense of a position by an army in the field. In the former case, the defender chooses points of resistance situated in rear of the crest, so as to be, as much as possible, sheltered from the artillery fire of the besieged; in the latter, these points of resistance are chosen so as to menace the flanks of the troops who try to pass them, and they are consequently to be found either in advance of the first line

of battle, or on this line. An intrenched village situated in the rear of the crest, would doubtless be less exposed; but it would also produce less effect."

The French sorties from Paris and Metz were directed against a continuous investment line, so that while they exposed their own flanks they could not attack that of the Germans. The German positions were so chosen and fortified as merely to gain time to concentrate their troops in superior numbers, before attacking and driving back the French. Again and again we read how the French sorties were stopped and driven back, not so much by the frontal fire, the retired positions of the Germans, as by the physical obstacles they encountered, and the counter-attacks made on their flanks.

The Duke of Wellington, in retiring his line from the crest, aimed at gaining the effect of surprise, and much of his success was due to this element and to the fact that the French attacks were made in column. No one can assert that the same success would have been obtained against deployed troops. It was due more to the vicious attack formation of the French, and to an intelligent use of fire by the English, than to the fact that the principal line of resistance was in rear of the crest.

The moral effect of retiring from the crest must be considered. The troops in the main line, in rear of the crest, would hear the fighting without seeing anything for some time. They may even receive stray shots, to which they cannot reply. Their minds get in a state of anxious tension, the imagination being worse than the reality, and when suddenly they see the

troops who were on the crest come running back, the effect must be demoralizing.

It is of great use to fire on the enemy's reserves when they can be seen, even at short ranges, for if they can be forced to retreat they will always draw back with them the lines in front. It is only by holding a crest line that this fire can be obtained.

If the principal line of defense be in rear of the crest, as soon as the troops are withdrawn from that line the enemy can mass his troops unseen at any point he likes. If he finds that he cannot advance beyond the crest, he can find shelter behind the crest from the defender's fire, and can throw up shelter-trenches and epaulments. The attacking artillery could even fire indirectly over the crest, having the effect of fire signaled. Modern battles are tending to increase in length, and modern infantry will carry intrenching tools; and the assailant, under cover of the night, can move troops around the defender's flank and throw up earth-works, so as to carry on the fight the next day on more equal terms. As the attack presupposes a superiority, even night attacks could be attempted at so short a distance with every chance of success. The defender, not being able to see whether his flanks are being turned, must immobilize troops on both flanks, where they will have to be kept until the attack is well developed.

The advocates of holding the crest lay great stress on the importance of the extended view of the enemy's movements and broad field of fire which it gives.

If the crest is occupied, the defenders will take care to cover

themselves, either with natural shelter or intrenchments; the echelons in rear will be similarly sheltered; the assailant is fully exposed during his advance, and his movements and dispositions can be seen; he cannot see the rear echelons of the defender, while any of his own echelons can be fired on; the defender can utilize his rifles and artillery up to their full range; he can watch the effect of his fire, and regulate it if it is ill-adjusted; the time for counter-attacks can be well judged; the artillery of the attack must cease firing when its infantry arrives near the crest, and as the fire of this infantry passes well in the air beyond the crest, the supports and reserves can easily come up in safety; if the artillery of the defense is overpowered, it can temporarily retire and reopen when the attacking artillery has to stop firing; and a commanding position adds to the moral force of the troops holding it, by giving them a feeling of security, and lessens that of the attack, which has, to fire at, only an imperfectly defined crest line, which changes with the range.

Crest lines for defense are always to be found, while suitable positions in rear are rare; hence the latter method must be the exception and not the rule. The experience of war sanctions the use of the crest, and no examples can be fairly given of the supposed terrible effects of inclined fire on reverse slopes.

The careful student will find the advocates of a position retired from the crest itself strongly supported by some of the arguments of their opponents. As the bullets fall further and further to the rear, they successively endanger every line of

the defense, if the crest itself be held; which will **not** obtain in nearly the same degree if the line of resistance be 700 or 800 yards behind it.

If the assailant can be induced to deploy equal strength along his front, his defeat is or ought to be assured by that **fact**.

Stone walls or houses on the crest would be battered down long before the attacking infantry arrived at the crest, and would thus in such positions lose the essence of their value—their use against infantry as keeps or reduits (just as Paquéé says).

The official reports of the French sorties from Paris do not at all indicate that they failed either from the difficulties of the ground or from counter-attacks in flank, but from the **fact** that the Germans chose their defensive positions so that the French were unable to carry them with infantry alone, while their artillery could not aid them. It would seem that a position retired behind the crest ought at this day to give the same element of surprise said to have been found so valuable by the Duke of Wellington. The assailant, after gaining the crest, would still find himself suddenly confronted by an **unshaken** line of infantry, backed by the other arms, from which he himself could for the moment at least derive no assistance; and from this array he would receive a fire which would reach him even if he recoiled behind the crest.

The infantry which held the crest lightly, if retired at the proper time, would retire without special danger, since it would then be in a protected zone, and it ought not, therefore, to

produce any injurious moral effect on those who occupy the principal line of defense.

If the fire from the retired line sweeps the slope in front of the crest (which as we have seen is a condition pre-supposed) the reserves of the attack will be quite as well fired on as they could be from the crest. In fact, firing on the reserves from the crest involves a division of the fire of the defense which is likely to weaken its effect on the firing-line of the attack, without corresponding effect on the reserves.

The defender should never content himself with a passive defense. When the troops of the attack, reaching the crest, are stopped and held there by the fire of the main position, the defender should take the offensive in force, not merely by partial counter-attacks; which ought effectually to prevent the massing of troops by the assailant for further movements, under cover of the crest.

As to the extensive view and field of fire, no one proposes to abandon the first, and if the second extends to 800 yards it covers the ground on which the battle must be fought out.

The fact remains, however, that crest lines for defense are more usually to be found than plateaus or very gentle slopes behind them, and probably on that account the usual procedure will be to hold the crest and to protect the reserves as well as possible by cover either natural or artificial.

Arguments for Holding a Line in Front of the Crest

Troops defending a slope should always see its foot. The loss of the Rotherberg spur during the war of 1870-71, and of the Majuba hill in the Boer war, illustrate the danger of a different procedure.*

It may be necessary, for this purpose, to advance the firing-line somewhat down the slope, to what is called the military crest as distinguished from the true crest.

Placing troops in this manner, two or more lines of infantry fire from shelter-trenches can be obtained, and the artillery brought into action on the crest. In order to hit any one of these, the fire of the attack must be specially directed on it, from the small depth of the dangerous zones on such (rising) ground.

In this case, the advanced position of the firing-line may be said to arise from the necessity for a clear view of the foot of the slope; but cases may arise where the slope of the ground is such that this disposition is deliberately chosen in order to use two tiers of fire and to utilize the crest to cover reserves and artillery.

The strength of such a disposition on favorable ground is illustrated by the battle of Fredericksburg. There the Confed-

*In both these cases there was a "dead angle" at the foot of an apparently inaccessible hill, where the defenders thought themselves safe from attack; and in both cases the assailant's troops, collecting unwatched in this angle, scaled the hill and carried its summit.

erates held a stone wall banked with earth, at the foot of Marye's Heights. The slope above was occupied by infantry, and artillery crowned the crest. When Federals advanced to the attack, the fire of the first line and the converging fire of the artillery swept the ground with such a storm of lead and iron that the attack was doomed to failure from its inception, and the first line, held by only 2500 men, was never endangered. The losses in that battle show a disproportion which conclusively proves the advantage of this method of occupying suitable ground.

The infantry line being well down the slope, the enemy would have no reason to fire on the crest; hence the reserves of the defense could safely be kept close in rear of this cover, and from their elevated position they can see when and where their action will be most opportune.

While the firing-line forces the assailant to deploy and to bring up his reserves in plain sight and under fire, the reserves of the defense can be moved safely and unseen on the plateau, and, if necessary, can be used to fire over the heads of those in front.

The position of resistance can be taken so far in front of the crest that artillery in its rear, on the crest, will be safe from the infantry fire of the attack as long as this position is held.

Enough has been said to indicate the great importance of knowledge of the ground and of its employment, both defensively and offensively. "Knowledge of the ground is no less indispensable to the attack than to the defense—here to profit by strong points, there to avoid them. The ground dictates to

the defense the points of resistance and the tactical dispositions; it indicates to the attack the direction in which an assault has no chance of success, and that where it may succeed. Tactical dispositions ought to be based on the properties of the ground; an ideal formation on horizontal ground would be annihilated if it were blindly placed on intersected ground; there is no panacea applicable to all cases."

The Germans enumerate among the qualifications of an officer, "correct appreciation of the ground."

The French Regulations say, regarding the occupation of —

1st, *Ground falling with respect to the enemy's line of sight:*

"The most favorable ground for defense is one which presents, in front of the firers, a clear glacis, forming a free field of fire of great extent, inclining gently toward the enemy.

The greater the fall of the ground in rear of the crest, the better are troops on this reverse slope sheltered from the fire of the attack. To cover steep slopes with fire, it must be delivered at long ranges, which lessens its efficacy.

Slight undulations of the ground hide troops from the view of the enemy, but not from his fire coming over the crest.

The firing-line should be sufficiently in advance to overlook the ground, and to leave in its rear a sufficient mask to protect the reserves.

A position which forces the artillery of the defense to come very close to the firing-line, while that of the attack can fire from its normal distance, is defective or badly occupied.

If the ground in front of the crest has a steep slope, stages

of fire can be used if the fire of the upper lines does not endanger the lines further down the slope.

Troops in rear of the crest must not think themselves out of reach of the enemy's fire because they are out of his sight. If there is no shelter, they should take formations with a narrow front. They remain at a distance when the enemy fires at long ranges, and as he advances they approach the crest to avoid the effects of his fire, which falls further to the rear as the ranges decrease. This forward movement suits the tactical necessities of the fight.

Observation of the points where the enemy's bullets fall furnishes a useful indication of the positions to be avoided by the reserves, because these points depend on the form of the ground, and not on the will of the firers.

In choosing a second line of defense, when it is not determined by the nature of the ground and the existence of natural obstacles, the distance to which it will be possible to sweep the slopes in advance of the crest must be considered.

It is at these distances, measured beforehand, that the shelter-trenches or other works of this second line must be constructed. They will so much the better permit of stopping pursuit and re-establishing the fight as the enemy's artillery comes more within the efficacious zone of infantry fire, which will prevent its coming into action."

2d. *Ground rising with respect to the enemy's line of sight:*
"Ground of this nature is favorable to the carrying out of the fight principally by the firing-line.

On such ground, column formations of any kind are eminently vulnerable and line formations with intervals are preferable.

The distance between the different lines may be less as the inclination of the ground is greater.

Troops in rear of the firing-line will, as a rule, suffer only from fire especially directed on them.

They ought therefore to use every accident of the ground to cover themselves; if there are no shelters, they will find that, in joining the firing-line, their best protection is an uninterrupted forward movement, rapidly crossing the diminished dangerous zones. This also enables them, by a single forward movement, to get away from any regulated fire of the enemy.

Finally, it should be pointed out that such ground has the grave disadvantage of exposing all the defensive dispositions to the enemy's view, who can see all the movements made in the interior of the position."

The Germans have made considerable experiments on inclined fire against the attack formations of their probable enemies, but the results are kept a profound secret.

In point of fact the whole question of the best method of occupying ground is not to be settled in the study on theoretical grounds. Each case must be worked out on the ground to which it is to be applied; and the skill of the commander is shown by the manner in which his dispositions are adapted to the ground.

CHAPTER 8.—LONG-RANGE FIRE.

The modern rifle can kill, if it hits, at ranges beyond 3000 yards. On the practice ground, it can be directed with some accuracy up to 2000 yards.

Examples from Franco-German War.—In 1870-71, the French were armed with a rifle superior to that of the Germans. Aware of this fact, and largely relying on it, they used a rapid long-range infantry fire, to which the Germans could not effectually reply, their rifle being sighted only up to 440 yards; and there is no doubt that this fire occasioned heavy losses in the close-order formations at first used by the Germans for attack.

Not even their victories in two wars show the splendid training of the German army so plainly as the manner in which they modified their formations, and, finding success impossible in the close order to which they were accustomed, adopted extended order on the battle-field itself.

“The Prussian Guard, in its attack on St. Privat, was formed with skirmishers in front, and two lines of half-battalion columns in rear. They lost 6000 men in thirty minutes, from rifle fire at ranges between 1500 and 600 yards, and were unable to advance to closer range until the French flank was threatened.” Other examples could be found in the same war of a corresponding effect of rapid long-range fire on dense formations.

Examples from Turko-Russian War.—In the war of 1877-78, the Turks were armed with a better rifle than the Russians, and they carried long-range fire to an extent which had never been seen before. They were provided with immense quantities of ammunition, which they used in firing at all distances up to the extreme range of their rifles, and their fire, it is said, began to be felt even at 2500 yards. The Russians used deep-closed formations. General Todleben says: "The fire of the Turkish infantry fell like hail at distances above 2400 yards. Divisions of 10,000 were reduced to 4000 or 5000 men." At 1700 yards the losses became considerable, and as the range decreased the fire grew hotter and hotter.

In 1870-71, the losses of the Germans decreased as the attack drew nearer to the French positions, and the range of the German rifle was reached. The French had no fire discipline; much of their fire was unaimed; many rifles were fired from the hip; and as the Germans drew nearer, a great part of the fire passed over their heads.

Opinions vary as to the effect of the Turkish fire at long and at short range. In the earlier battles, in which the Russians did not fire while advancing, its effect seems to have increased as the range grew less; but later, when the Russians fired during the advance, they seem to have met with less loss at the shorter ranges.

In both these cases the firers were uninstructed in making the best use of long-range fire. They seem simply to have fired away, trying to break the force of the attack, and to inflict as

much loss as possible. As long as the attack presented deep-closed formations, the effect of the fire was great; but on extended formations it never prevented a resolute advance from reaching the decisive ranges, or ended in the defeat of the assailant: and both these wars show armies better armed than their enemies, suffering one defeat after another, in spite of all the losses caused by their long-range fire.

But neither the French nor the Turks were trained to make the best use of such fire, and from the results which they obtained the idea has been derived that, when infantry are well trained for the purpose, their fire will be effective up to very long ranges.

Should long-range fire be used at all? If so, up to what ranges?

The Germans divide ranges into

The short zone, 0 to 440 yards;

The medium zone, 440 to 770 yards;

The long zone, 770 to 1300 yards.

With our present rifle we may divide them into

The short zone, 0 to 400 yards;

The medium zone, 400 to 800 yards;

The long zone, 800 to 1300 yards.

Distances beyond 1300 yards may be eliminated. Results may be gotten beyond this, but they will be uncertain and indecisive at best, and will entail an expenditure of ammunition which is tactically never justified by the effect produced.

Most men cannot see further, and fire at unseen objects has but one reasonable application—in sieges.

This statement, of course, is not absolute. Cases may arise where the defenders of a position can be supplied, like the Turks at Plevna, with unlimited ammunition; but until they do arise, the limiting range may be considered 1300 yards. Beyond this the action should be left to the artillery.

The short zone is that of individual fire, which ought not to be used in any other place.

In the medium zone, fire will be used by both the assailant and the defender. It must be carefully controlled and concentrated. Here the fire of groups is especially suitable and important.

Our question, then, refers to the long zone, between 800 and 1300 yards.

Use of Long-Range Fire by Defender.—1. The defenders of a position ought to know the distance of the various landmarks in their front. A good view to the front is one of the qualities of a good position. The replenishment of the ammunition is comparatively easy. It would be throwing away one of the properties of the rifle not to fire if suitable objectives present themselves, such as troops in any dense formation of considerable size. By this means the close-order formations of the assailant will be forced to deploy, his troops wearied, his advance delayed, his strength shaken, and his morale injured.

But such fire should be strictly controlled, and permitted only when it does not endanger the supply of ammunition in

the decisive stage of the fight. No battle can be won by distant fire; it must be fought out at the short ranges.

If the defensive position be retired, as Paquié advises, some 50 yards from the crest, all this long-range fire will fall to the lot of the advanced line holding the crest itself. These should force the assailant to deploy, develop his plans, and delay his advance, and thus weary his troops as much as possible; then, falling back, they would leave the decision of the fight to the issue of resistance, to be fought out, as it must be, at decisive ranges.

Boguslawski says of the French in 1870:

"The soldier was taught to fire at long ranges, and thus fell into a fault which is sure at all times and under all circumstances to meet with its punishment. The long range and rapidity of fire of the chassepot were the only qualities of which they sought to take advantage. *They paid no attention to those elements of a sound system of shooting—steadiness, careful practice, and economy of ammunition.*"

Again:

"The French, who extended very strong swarms of skirmishers, opened their musketry fire at very long ranges—from 100 to 1400 paces. It is true that even at this distance we had men killed and wounded, and that this surprised our people pleasantly. It would be a mistake, however, to draw any positive conclusion from this. If you look into the matter closely, you will find no case in which our troops were really

shaken by fire at such distances. . . . *The advance of German infantry was never once checked in this way.*"

And again:

"Our habit of allowing the enemy to approach much near and then commencing our fire never failed to produce a wonderful effect; . . . and when we followed out our principle of reserving our fire, we always got the best of it."

By Assailant.—2. The offensive should be prepared concentrating on the principal points of attack such a fire will silence the artillery and unnerve the infantry of the defense; then follow the advance and assault, which should be carried out with all possible vigor and speed. If the troops could be brought up to close range without firing at all, would be an advantage, but practically it is necessary to allow some firing when once seriously exposed to the enemy's fire. We must take human nature into account; and human nature in the assailant greatly objects to being shot without trying to reply, and in the defender leads to much less careful aiming when he himself is being shot at.

Therefore we cannot expect to bring the attack up to 400 yards without firing; but if those who are to make the assault begin firing beyond 800 yards, they will produce no practical result, except to exhaust their ammunition and to lose the forward impetus. The fire of the advancing assailant should first be opened as near the position as possible—never beyond 800 yards—and then under strict control. It is a medium range fire.

A reply to those who deduce from the war of 1877-78 a belief in the efficacy and value of fire at very long ranges is furnished by those who suffered most from such fire. The Russian regulations, published after that war, say:

"Judicious employment of fire is the only guarantee of success. The accuracy of the rifle produces its full effect only when the objects chosen are suitable to the range.

The long range of the rifle must be used with the greatest prudence. It must be borne in mind that short-range fire alone has any real precision and decisive importance in battle, and that long-range fire is useful only against unusually favorable targets, which, under this fire, promise results commensurate with the expenditure of ammunition. In the offensive, it is very difficult to estimate the ranges, and doubtful whether the ammunition can be replenished at need, and therefore long-range fire should be employed only with the greatest circumspection.

In the advance, the object should be to reach, as rapidly as possible, a distance from which really efficacious fire can be opened; hence the firing-line should gain this distance as nearly as possible without a halt."

"**Fire of Position.**"—A rapid advance may avoid loss for a while, but only steady fire can inflict it. But speed of movement and steadiness of aim cannot go together; to attempt to combine them in the assault is to sacrifice both.

The preparation of the attack cannot be too complete. Captain Layman says (The Frontal Attack of Infantry): "We now

know what a frontal attack against a position defended with breech-loaders signifies. If we have determined to undertake this task—in any case the most difficult and sanguinary for which infantry can be employed—then the least we can do is to make the most careful preparation, in order to secure the greatest possible chance of success.”

If, in this preparation, the efforts of the artillery are deemed insufficient, they may be supplemented by detaching bodies of infantry to advance and occupy suitable positions, and assist by their fire in the preparation.

The attack requires a preponderance of fire. In order to combine rapidity of advance with efficacy of fire, to secure preponderance of fire without exhausting the ammunition of the troops charged with the assault, and to assist the artillery in preparing the attack, it has been proposed to employ distinct bodies of infantry to prepare and cover the advance, and keep down the fire of the defense. These auxiliary bodies would be established under cover at suitable ranges (1300 to 700 yards from the position, where they could be supplied with ammunition with comparative ease.

Fire executed by special troops in this manner is called in Europe “Fire of position.”

This name has been given to long-range fire executed by stationary troops, to facilitate the march of the troops of the assault, and aid them in the execution of their task.

This definition, which is correct but superficial, must be com-

3d. Fire of this nature, to be advisable, must fulfill the following conditions:

1st. It must be necessary and efficacious.

2d. It must produce an effect which it could not give at shorter range.

3d. It must possess some quality lacking in the fire of the frontal attack. The troops which execute it must render more service by their fire at a distance than they could by advancing to the enemy, or by establishing themselves at shorter range.

Now there are circumstances under which all these conditions are entirely fulfilled, and others where they are not; fire of position is judicious in the former case, and senseless in the latter.

What possible object can be attained in an attack on a level plain, for instance, by fire of position delivered at long range? What quality has this long-range fire which is lacking in that of the troops in advance? In what respect do troops thus situated at long distance render more service than they would if nearer?

No satisfactory reply can be given to these questions, for under such circumstances the fire of position is less accurate than that of the attack, the dangerous zone is less, the beaten ground is the same, the ricochets amount to nothing; consequently, by firing at 1200 or 1300 metres from the hostile position, cartridges are consumed beyond efficacious range, which would produce a greater effect with less elevation—which is a great waste of ammunition. It is difficult to understand ma-

mœuvres of this sort, for to employ at long ranges troops who could act nearer is a poor conception, which results in a loss, and not in an increase of strength.

Proceeding by elimination, we find that fire of position is not applicable either when the assailant's line of sight penetrates the ground of the position or when it is parallel to the surface of reception.

Fire of position should be used at the ranges where it is most efficacious. Its power will be strongly felt, without any necessity for going beyond the efficacious range of the rifle, if the ground of the position makes a descending angle with the line of sight. Let us illustrate by a position of 50 metres command against which a frontal attack must be pushed home.

On the principles of inclined fire, the efficacy of the fire executed at a range beyond 700 metres will be greater on the summit than if the surface of reception was on a level with the firers: the dangerous zones will be more extended, and the beaten ground deeper, without giving rise to any defiladed zone behind the crest. But to arrive at a solution and drive off the enemy, it becomes necessary to advance and cross the limit of efficacious long-range fire.

From this moment the fire of the assailant begins to rise more and more above the summit, searching, it is true, without sparing anything, all the rear of the position, but leaving between the crest and the point of fall a defiladed zone, in which the supports and reserves of the defense may find shelter.

It then becomes highly important to suppress this zone, and

the object is attained by filling the space left by the fire of the frontal attack with fire of position, delivered from such a distance that it will effectually beat the ground immediately in rear of the crest. This distance is not difficult to find, since it is indicated in hundreds of metres by the square root of the relief. In the case assumed it must be at least 700 metres, and an error of 100 metres in excess will not cause any especial inconvenience.

In such a case we see a simultaneous employment of two lines of sight by two different echelons, but their fire is directed on the same object (the troops on the crest); it is concentrated both in height and in direction; its sheaves of trajectories overlap and succeed each other, sweeping the defensive position throughout its depth; in a word, it is a logical combination of the effects and tactics of fire." (Paquié.)

The Germans did not hesitate to fire over the heads of advancing troops, when they could not get fire of position from the flank. This procedure was not entirely approved, and would be impracticable on ground parallel to the line of sight. In the attack of a commanding position, however, the elevation of the line of sight is added to that of the projectile, which passes high above the troops in front; and the fire at long range has great power, the dangerous zone of fire from below on the crest being greater than those of fires from the crest on the plain in the proportion of 10 to 1. Such an advantage would not be neglected when it could be utilized.

But, it may be said, the top of a height is rarely horizontal;

it may present an angle, either ascending or descending,* and the range ceases to correspond to the square root of the relief, since this depends on the angle between the line of sight and the surface of reception.

The reply to this objection would be that a relief of any profile can be more efficaciously swept at moderately long range; it is a question of correct estimation of the ground; if the ground rises in rear of the crest, the range should be diminished; if it falls, the range should be increased; the secret is to take advantage of that curvature of the trajectory, or, in other words, of that elevation, which produces the maximum of efficacy.

A phrase from the German Regulation sums up the question, and shows profound knowledge of the effects of musketry in varied grounds:

“The choice of elevation depends on the inclination of the surface of reception with respect to the line of sight, and the extent of this surface in depth.”

Influence of Depth.—We have seen what was the effect of the inclination of the beaten ground; we have still to consider the influence of its depths on the choice of the range. If inclined fire is directed on a very deep surface, for instance, on the edge of a wide plateau, the best results are given by a grazing fire, rising only slightly above the surface; if the fire is directed

*Neither rise nor fall is likely to be very great, in a selected position.

on an undulation with a depth of some 200 or 300 metres on the summit, the range must be increased, in order to sweep the summit and to suppress the dead angle which the grazing fire would produce.

Thus, against a plateau a distance of 700 metres might be most favorable, while against a simple undulation, of the same relief, 800 or 900 would be better.

“Fire of position thus directed produces an effect which that of the frontal attack cannot give, and it possesses a quality which is lacking in the latter; it is therefore necessary. Its trajectories cover a greater depth and are therefore more efficacious, and the troops which execute it render better service than they would at shorter ranges. If these conditions are not fulfilled, the fire of position loses its value.”

“The value of tactical dispositions depends on their fitness for the ground. We have shown this by the fire of position, which, efficacious and necessary under certain topographical circumstances, loses its value in all other cases. If we would avoid grave errors, it is indispensable to remember that, so far as the action of fire is concerned, the configuration of the ground is equally important with accuracy of fire.”

General Rules.—In all that precedes, no attempt has been made to lay down absolute rules for the range at which fire may be opened. Cases may arise for which no general rule can be made. Thus, in preventing the occupation by the enemy of a defile of any sort, the distance of which can be as-

certained, the long range of the rifle can be utilized in concentrating on it a cross-fire from many points; or tactical errors of one party may expose heavy masses to the fire of the other, which will then produce a powerful effect up to 2000 yards. It will be the duty of the commander of the firing-line to decide, and one of his most valuable gifts to decide wisely, when the fire should begin.

But, taking a general case presenting average conditions, we may say that—

1. No infantry fire should be used beyond 1300 yards. That role should be left to the artillery.

2. Fire between 1300 and 800 yards is chiefly useful to the defense. If used by the attack at all, it should be by strong parties well posted and supplied with an abundance of ammunition. In any case it should be kept under rigid control, and concentrated on suitable objectives.

3. Between 800 and 400 yards, the fire of the defense rapidly increases in destructiveness. It should be controlled and concentrated. The attack will be forced, for reasons already given, to commence firing between these ranges—the nearer the position, the better. Control and direction of fire should be maintained, the assailant being exposed to the danger that, halting to fire in an apparently favorable position, his firing-line may lose its forward impulse, and that if the firers once escape from control, all the cartridges may be expended in a fire which cannot accomplish the object of the attack.

4. Every effort should be made to retain this control and direction. The time when uncontrolled fire becomes inevitable should be delayed as long as possible.

The endeavor of the following chapter will be to give some further reasons for doing this, and to indicate how it may be done.

CHAPTER 9.—DIRECTION AND CONTROL OF FIRE.

“The source of victory is in superiority of fire”; and the chief source of this is in concentration. With this purpose in view, the long range of the rifle should be utilized to concentrate on objectives successively chosen, the fire, not only of the troops immediately fronting them, but of considerable fractions of the firing-line.

That this may be done and results obtained commensurate with the ammunition expended, the fire must be directed and controlled.

Classification of Duties.—The functions of those concerned in the firing may be classified as follows:

To the commanders of the firing-line, belongs the direction of fire.

To the commanders of subdivisions, the control; and

To the men, fire discipline.

The French Regulations say:

“The duty of controlling the fire falls on the commanders of the companies in the firing-line and on the officers employed there.

The captain determines the objects to be fired on, the nature of the fire, and the fractions of troops to be thrown into the firing-line during the whole period of preparation. While

leaving to the officers under his orders the necessary initiative for the execution of the duties which he has assigned them, he watches that the fire does not deviate from the direction which he has assigned to it, and tries to control it up to the last moment.

The sectional commanders, according to the orders they have received, indicate to the men the sights to be used, point out the objective to be aimed at, the number of cartridges to be fired, and regulate the intensity and duration of the fire.

The duty of commanders of smaller units (*i. e.*, groups) is to see that the orders are carried out concerning the sights to be used, the objective to be fired on, the pauses and re-opening of the fire—in a word, to assure the execution of the orders.”

The German Regulations say : “ In action, the utilization of the rifle, as long as control of fire exists, belongs to the leaders. A rational employment of fire is one of the essential guarantees of success. The necessary conditions to obtain it are calmness, tactical judgment, skill in estimating distances, gift of observation, correct appreciation of the ground, and knowledge of the ballistic properties of the weapon.”

Direction of the fire includes : (1) the determination of the moment for opening fire ; (2) choice of objectives, and their allotment to the troops firing ; (3) choice of the ground to be occupied by the men ; (4) the designation of the elevations to be used ; (5) the kind of fire to be used ; (6) observation of the results obtained ; (7) the number of rounds to be fired at each

halt in advancing to the attack; and (8) replenishment of ammunition.

Control of fire means enforcing these orders, and seeing that the men take careful aim with the designated elevation at the designated object.

Fire discipline is, or should be, the unhesitating habit, developed in the men by instruction and training, of commencing, relaxing or ceasing the fire, and concentrating it on the designated objects, in obedience to orders. No firing should ever be permitted without orders, and it should cease as soon as that command is given.

In the German and other continental European armies, where the company numbers 200 to 250 men, the tendency is to throw the duty of direction of fire on the section commanders in the firing-line, leaving the control to the group leaders.

Difficulty of Maintaining.—The complete maintenance of such a subdivision of duties is possible only at some distance from the enemy, before the irregular mixing of units which sooner or later occurs. That control may not be speedily lost, men must be taught in peace practices to obey the rank, and not the person merely, so as to accustom them to follow strange leaders when their own are lost. "Two things are necessary for this: (1) that the soldier should be taught the limit of efficacy for individual fire, its uselessness beyond that range, and the efficacy of a collective fire; and (2) discipline—the key note of all success in war."

(1) **The Moment for Opening Fire.**

General Rule.—It is impossible to lay down definite rules for this purpose. It will depend on many circumstances, among which are the size of the target offered by the enemy, the supply of ammunition and the means of replacing it, the phase of the fight, and the moral condition of the men. Cover may be available which will permit the attack to approach to shorter range before the assailant is compelled or the defender able to commence firing. The general rule is to reserve the fire as much as possible for the decisive ranges.

Prepared Positions.—If the defender has taken up his position and prepared it at his leisure, the ranges in his front will be measured, and noted by such land-marks as may exist. This confers on him the obvious advantage of efficacious fire at considerable ranges, which the artillery preparation of the attack is intended to neutralize. This advantage will be utilized by the defender, not only for the sake of the actual loss which it enables him to inflict on the attacker, but also in order to compel the latter to undergo the fatigue and delay of early deployment and a long advance in extended order.

The Assailant.—In theory the assailant should open fire, not when the infantry of the defense becomes dangerous, but when his own fire becomes effective. This, in its fullest sense, would imply an advance without firing to 400 yards; "but the most determined advocates of this close fire admit that the troops of the first line can fulfill the requirement of getting

within effective range of the enemy, only when the ground is particularly favorable. Should it not be so, fire must be opened before arriving at 400 yards, that is to say, at some distance between 800 and 400 yards."

In the attack, opening fire at too long ranges diminishes the offensive power of the troops and gives a protracted character to the attack. An ineffective fire weakens the morale of the firers and raises that of the enemy; if the company commander sees that his fire is producing no effect, he should stop it, and wait for a more favorable opportunity for re-opening fire.

Expenditure of Ammunition.—"All commanders, but particularly those of units not yet within effective range of the enemy, should be careful to estimate the amount of ammunition needed to attain an object, and to consider whether the advantage expected will compensate for the necessary consumption of ammunition, and whether the strength of the firing-line is sufficient to accomplish the object intended."

"It should always be borne in mind that beyond 800 yards efficacy can be attained only by the expenditure of many cartridges. If the firers be few, this entails a great individual expenditure. Such fire should be delivered by the greatest number of rifles available. But when the order is given to fire on any stated objective, the number of cartridges required should be unhesitatingly used."

Demonstrations.—"In a false attack or a delaying action it may be necessary to keep up a lively fire at considerable distances, although there may be little hope of inflicting serious

loss. The object in these cases is to deceive the enemy, and hold him fast. The fire should be regulated accordingly, but the commander should take account of the expenditure, and provide for its replenishment.

The case may arise in which troops on the defensive have an unlimited supply of ammunition. Such ammunition will be used at any range where useful results may be expected, either in actual loss to the enemy, or confusion, delay and fatigue to his advance.

Preparing the Attack.—If the attacker is inferior in artillery, the infantry will have to prepare its own attack, either alone or as a supplement to the artillery. Such fire will be executed by as many rifles as possible, concentrated on the point to be attacked, and not allowed to diminish the complement of ammunition with which the troops who are to make the actual assault should be provided when they commence their advance. If any of this ammunition is necessarily expended it should be replaced before the advance begins.

(2) Choice of Objectives to be Fired On.

Difficulty of Selection.—This is one of the most difficult problems to be solved by officers in the firing-line, and, at the same time, one of the most essential to the proper direction of fire. So long as the enemy's dispositions can be clearly made out, it will be comparatively easy to make a judicious choice of the objective; but when many battalions are engaged side by side, though the dispositions may be clear enough at first, they

soon present a confused aspect, from the varying rate of advance of the different fractions.

Basis of Selection.—"However important different methods of its execution may be in influencing the efficacy of fire, this efficacy can produce a useful effect from a tactical point of view, only when it stops or paralyzes the enemy's movements, and breaks his combinations. However great the losses of the enemy may be, they are of little use if they do not prevent his final success. It is, therefore, important to reap from the efficacy of fire the greatest tactical gain; and this should be the principal object sought by tacticians, as their speculations will be of little avail if they do not give the means of securing victory.

In order that the losses inflicted on the enemy may produce their greatest useful effect, they should be inflicted on those groups which by their role, strength and situation can exercise a serious influence on the course of the action. These, as opportunity occurs, should be destroyed or weakened. It may therefore be said that the greatest tactical result of the efficacy of fire depends on the proper choice of the objectives.

The question of the choice of objectives is a capital one: it dominates all others in connection with the direction of fire."

Assailant.—The choice of objectives for the assailant is practically determined by that of the point of assault. His objective will usually be the defender's firing-line at this point: but if the supports and reserves of the defense appear in sight, the assailant should fire on them, both because they are likely to



DIRECTION AND CONTROL OF FIRE

present good targets, and because of the moral damage done to them.

Defender, First Rule.—The defender, if the ing a serious attack in his front, will fire on the of that arm which, for the moment, constitutes th of the defense, if this echelon be within effective

Against a Demonstration.—The necessit ating large forces in that part of the battle-field sault is to be made causes a relatively small po to be available for other parts of the assailant's can then have only a demonstrative role; their not press forward very far, and its fire will be n efficacious. In this case, the firing-line should as to prevent its attempting to change the demor more serious attack; and, this purpose accomp the defender's fire will be available for other ob

Fire thus liberated should be so directed as to r flank fire on those of the assailants who are n attack on neighboring portions of the positior within even long rifle range. Such fire has gr material and moral. "Even the sound of bullet flank will intimidate men, and cause them to h dvance."

Flank Fire.—Modern battles on a large sc eries of small fights. These rage round the s e position, which act as bastions along the fro powerful cross and flank fire can be poured o

to penetrate between them. The assailants try to work round the flanks of these, so as to surround them, but in so doing, they expose their own flanks to the defending troops in the intervals. Thus a skillful defender will find many opportunities of using a flank- and a cross-fire with great effect, and the objective for this fire should be one which, if destroyed, will have the greatest effect in rolling back the advance.

Against a Frontal Attack.—Returning now to the supposition of a serious attack in front, we must choose among the different groups which will appear there. The firing-line, though weak at first, will soon become menacing. Behind comes the second echelon or support, which, joining the firing line, carries it forward to the zone of efficacious fire, where they prepare the final phase of the fight. Further in the rear come other echelons, who reinforce the supports, follow their movements, and wait for the moment of assault. Confident in their numerical strength, and stimulated by the progress they see, they join in their turn the most advanced groups, and giving them an energetic impulsion, they push on the mass of the combatants to the assault of the position.

Second Rule.—The duty of the firing-line is to open a way for the echelons in rear.

It exercises a considerable influence on the course of the fight, "as a bold or timid advance communicates itself at once to all the dispositions, . . . success or defeat can almost be foretold by it." Hence the second rule will be to choose

the first objectives among the groups of the nearest echelons which threaten the greatest danger.

General Skobelev said to his troops: "Even in European wars it is most important to observe the foremost groups of the enemy; it is not really the mass of individuals present on the ground that decides victory, but the progress which a few brave men may make advancing in isolated groups. Consequently, every attention must be paid to the appearance of groups of this nature, and direct on them, by means of volleys, the full power of the fire; for if you neglect to inflict great losses on them, these groups will . . . increase in size in a wonderful way and decide the affair in their favor. . . . I counsel the leaders of all fractions to keep a watchful eye on these advanced groups; there is not a doubt that in annihilating them we destroy, in the germ, all the initiative power of the rest of the mass."

Exceptions.—But there are exceptions to this second rule. When the attack begins with an artillery duel, the infantry covering the assailant's artillery will be neither near enough nor strong enough to be a source of serious danger. At this time the artillery, offering wide and deep objectives, may be fired on by the defendant's infantry with good results, if the latter be well posted and know the ranges.

During this time, mounted officers are sent to reconnoitre the position or to carry orders, and if possible they should be shot, so as to delay the elaboration of the plan of attack, or its execution.

Thus the first exception will be to fire on the guns or on mounted officers, if within range, during the preparatory stage of the attack.

When the fire of the defenders causes the enemy's firing-line to halt, the second echelon comes into action. Up to this point, the supports will have sheltered themselves as much as possible, but in approaching the firing-line they must show themselves, and they should then be fired on, as their destruction will prevent the advance of the firing-line. If the second echelon fails to carry forward the firing-line, the third will be similarly used, and should then be fired on for the same reason.

Thus the second exception will be, when the most advanced echelon of the attack can no longer advance, then select objectives in the second and third echelons as they advance.

Or if the firing-line is halted for any reason, and offers very bad objectives, then the fire may be directed on objectives in the second or third echelons, if suitable ones can be found.

Importance and Vulnerability.—The groups in the echelons selected may not at all have the same importance or vulnerability, and we must consider which to select as the objective. Vulnerability in this connection depends on the size and the formation of the groups, and the cover available for them.

The first consideration in the choice of objectives is their tactical importance; and in order to make a good selection officers must understand the influence which the different arms and even small units of them exert in the different stages of the fight.

If the tactical importance be equal, the group most vulnerable

at the time should be fired on, and when it has been destroyed or checked, the fire may be directed on another, which will meanwhile have become more vulnerable by decrease of the range.

Concentration.—Too frequent changes of objectives cause a loss of time and lead to a scattering of losses which robs them of much of their moral effect. Hence as far as possible having chosen an objective, the fire ought to be kept on it until it is destroyed, or at least temporarily paralyzed.

At close ranges the men will fire only on the echelons nearest them, which will then appear to them most dangerous, and they will then be too excited to change their aim to other objectives.

(3) Choice of the Ground to be Occupied.

Each of the tactical units in the firing-line will usually be restricted to a front imposed by the presence of other troops, and a line of advance leading to the portion of the position designated for its attack.

On that line of advance, however, there may be a considerable latitude for choice in the location of the temporary halts. The general relations discussed in chapter 7 should be remembered in making this selection.

Cover should be used as long as it does not interfere with the purpose of the action—defeat of the enemy. Shelter from his fire is secondary; the firing-line should therefore not be halted behind any cover which hides the enemy from view.

(4) Designation of the Elevation.

Importance of Knowing Range.—The efficacy of the fire of masses of men depends more on knowledge of the range than on the skill of the individual firers, the first being a fixed quantity, and the other a variable factor, never very reliable in action at the best of times, depending as it does on the physical and moral condition of the troops.

The importance of this knowledge makes it incumbent on the defender to measure the distance of any prominent objects in his front from the various portions of his position,* and on both defender and attacker to use every endeavor to ascertain the ranges. Information should be asked from the nearest troops, especially the artillery, maps should be consulted, range-finders used, and, on ground suitable for observation, trial volleys employed.

When the range has been determined as exactly as possible, the choice of elevation is made in accordance with the principles already stated. All experiments show that the better results are obtained when the fire is rather short, especially when combined sights are used.

Firing Down Hill.—Men firing down hill are apt to fire higher, when excited by the approach of the enemy, than those firing up hill, and a less elevation should be used in the former case than in the latter for the same distance.

Against Cavalry.—Against cavalry, almost all European

* In order to fire on the assailant as he reaches them.

nations prescribe that short-range fire is only to be used. The German Regulations say, that the 350 metres sight is to be used against cavalry, and the French Regulations the 400 metres. The Russians are more decided, for they forbid fire against cavalry at longer ranges than 333 yards. The reasons given for this, are:

1. The uncertainty of hitting, at longer ranges, an object moving forward with so much velocity.

2. At longer ranges the sights would have to be constantly adjusted, which causes loss of time.

3. The essential point is not so much to cause heavy losses among the mass of mounted men, as to break the dash or élan of the charge by bringing down a number of horses.

4. A body of cavalry exposed from the beginning of its charge to a fire of poor efficacy, is not influenced by any moral deterrent; but the opposite is the case when this body is kept under the constant menace of a sudden and terribly effective discharge.

The question naturally arises, if the cavalry charges in two or three lines, what will be the effect on the second line even if the first is destroyed within 300 yards? But it is difficult for us, without opportunity for experiment, to refuse assent to such a consensus of opinion.

(5) The Kind of Fire to be Used is Discussed in Chapter 10.

(6) Observation of the Results.

The German Regulations say that the strike of the bullets and the effect of fire should be carefully watched through field-glasses, in order to rectify the sights and increase the efficacy of the fire.

In observing the effect of fire, the direction of the wind must be taken into account, and it will often be advantageous, (especially when on the defensive and firing from intrenchments) to post observers on one side of the line of fire, who communicate with the firers, either by signals or relays of messengers. Such observers should bear in mind the following instructions, laid down in the French Regulations:

It will often be useful to regulate the fire practically by means of trial volleys, watching the effect with the aid of glasses. At first a sight for less than the estimated range should be used, which is afterwards increased, by 100 yards at a time, until the proper range is found.

In observing the strike of the bullets, it must be remembered that, in a well-regulated fire, half the bullets fall on each side of the object. Dust thrown up by the bullets in front of the object is therefore not a proof that the fire is too short; while the absence of dust, in a soil favorable for observation, is a certain indication that the fire is too long.

On undulating ground, the presence of a depression (the

bottom of which cannot be seen) in front of an object may make the observation of the strike very difficult. If the bullets strike in such a depression, no dust being seen by the observer, he may be led to think that the elevation is too high, while really it is too low.

When the observer is placed far out on the flank of the body of men firing, a fire too short, but good in direction, will appear to fall to the left of the mark for an observer on the right, and to the right for an observer on the left.

Conversely, a fire too long, but good in direction, appears to fall to the right of the mark for an observer on the right, and to the left for an observer on the left.

) The Number of Rounds to be Fired at each Halt in Advancing to the Attack.

Method of Advance.—Military writers are substantially agreed on two points—that the advance to the assault must be made in a succession of bounds or rushes, and that the advancing troops must fire during the halts which divide these rushes. Proportions might be multiplied to almost any extent on this head, but they are hardly necessary.

At the same time, after the preparation is completed, the attacking troops should move as rapidly as possible up to the short and decisive ranges.

“Distant and frequent halts are not good for troops on the offensive, because they break their dash, diminish their ardor, and cause them to be too attentive to their losses, which are

always deadliest at the halting-places, whose distances may be exactly known to the defense."

Granted that the men are to fire during the advance, what number of rounds ought they to expend until they come within the short ranges?

At about 250 or 300 yards they will engage in a rapid fire, which will last some four or five minutes, and during which upwards of 40 rounds will be fired.* They will need at least 20 rounds to complete a success or cover a retreat; so that, at 300 yards from the position, each man ought to have at least 60 rounds on his person.

Suppose the advance to take place from 800 yards up to 250 yards from the enemy, or over 550 yards.

If the enemy is very much demoralized, the advance may be continuous, the men running forward, either singly or in groups, to fire. At the rate of three miles per hour, it will take about seven minutes to cover 550 yards, during which about 14 rounds will be expended.

If the enemy's fire is still efficacious, the advance must be made by successive rushes of 30 yards.† This will give 18 pauses between 800 and 250 yards, and during these pauses they would fire. The pauses should be short, so as to give the attack all the vigor and dash possible, and to avoid losses, which

*This is a very small allowance for the Springfield rifle.

†Taking the shortest distance, for the sake of being on the safe side. See Drill Regulations.

are greatest at the halts ; but they must not be long enough to permit the advance of the rear echelons to be covered by fire, and the men of these echelons to get into position and open fire. Their average length should be about one minute, during which the sights may be adjusted to the range, and three rounds fired with deliberation. Hence, in such an advance each man would fire 54 rounds, requiring each to have on his person, when the forward movement begins, 114, or allowing for cartridges dropped, 120 rounds.

(8) Replenishment of Ammunition.

The importance of this subject is so great that it has been treated in a separate chapter.

CHAPTER 10.—KINDS OF FIRE TO BE USED.

The proper performance of these duties implies control of fire. The most perfect supervision will fall of its purpose unless supplemented by fire discipline; and it can hardly be too strongly stated, that the full value of the rifle can be realized only when the men have been thoroughly trained in this discipline.

Comparison of Controlled and Uncontrolled Fire.—Some theoretical advantages have been claimed for uncontrolled fire, from the fact that it allows the soldier greater freedom to fire when he likes, and at any objective he may select; that it gives the quickest and most continuous fire. These reasons would perhaps be convincing if a battle were to be fought, every man for himself, and if its object were the greatest number of shots in a given time.

But the object should be to use the fire of every man in such a way as to contribute most effectually to the purpose of all—victory; and there is likely to be far more need for restraining the consumption of ammunition than for stimulating it. General Skobelev says: "In the art of affording mutual action has always lain and will always lie the secret of victory." And again: "Do not forget the sacred duty among all, to give help at all costs, whoever your neighbors may be."

Disadvantages of Uncontrolled Fire.

1. It is almost always frontal and unconcentrated.
2. The losses which it causes being scattered, it produces least moral effect on the enemy.
3. It has a bad effect on the morale of the firers by causing an impression that danger is near; and as the ammunition decreases, so does the courage of the men, unless fresh troops or ammunition be forthcoming at this moment.
4. The sights cannot be readily altered, nor the fire directed from one object to another. This is especially important when the enemy's cavalry is to be feared.
5. It renders any advance almost impossible which was not in operation when the uncontrolled fire began.
6. It soon produces such a cloud of smoke as to hide the objective.
7. It conduces to excessive expenditure of ammunition, which there is no efficient means of checking.
8. When once begun, especially when near the enemy, it can hardly be regulated or moderated, and soon degenerates into a rapid and inaccurate fire.
9. There is no check on the elevation used, or the object aimed at, nor, indeed, any means of determining whether the men aim at all.

When uncontrolled fire is once allowed to begin, especially if the enemy is near, it is liable to continue till the last round is expended. At such a time the moral strain is intense, and the

inclination of the men is to fire as fast as they can, in order to keep up their spirits. In very heavy firing neither voice nor bugle can be heard, though it is said that a very shrill whistle can be used with effect. Uncontrolled fire should be avoided as long as possible, and to practice it at drill has been by some considered not only needless but harmful.

At short ranges any controlled fire will of itself degenerate into rapid uncontrolled fire, the men can no longer attend to orders for control, and the pauses will disappear. There is no need to order uncontrolled fire at such a time, for it is inevitable.

Advantages of Controlled Fire.

1. It is essential to the use of combined sights.
2. It permits a regulated change of elevation and objective.
3. It permits an offensive advance, at the opportune moment, from the defensive or halt.
4. It can be stopped to allow the smoke to clear off, when it gets too thick.
5. It checks the excessive expenditure of ammunition, and is the only means of doing so.
6. It is the only means by which there can be any certainty that the men are firing with careful aim at the designated objective with the proper elevation.
7. It enables orders to be given on the one hand and understood on the other.
8. It enables the commanders to concentrate the fire successively on the different portions of the enemy's line. The men

If left to themselves, will fire only at a prominent object in their front.

9. The losses will thus be concentrated, and will produce their full moral effect on the enemy.

Brialmont says: "Men in column are more powerfully impressed by losses than men in line, because the men killed or wounded in a deep mass are seen by more men than the same number killed or wounded in a thin line. This difference of moral effect is especially felt when infantry is exposed to artillery fire"; . . . to which we may add, "or concentrated infantry fire." A given number of men falling at the same instant will produce a greater effect on the morale of the remainder than the same number falling here and there, singly or in twos or threes.

Captain Mayne traces the bad shooting of English troops in recent wars to lack of control and consequent lack of concentration of fire. He says:

"The Boer war showed us the absolute failure, as could be expected, of our system of relying on the independent, unconcentrated fire of individual men.

"In Ashantee, our men in the bush fighting sometimes fired away 100 to 120 rounds in independent firing, with apparently small results. That is, they fired more ammunition individually than in some of the most hotly contested European battles. This was short-range firing, and such a number could not have been expended had the fire been controlled.

"In Afghanistan our troops, as a rule, opened an independ-

ent fire at ranges between 700 and 900 yards (as we had not then any such thing as 'fire discipline' in our service), and killed very few for the number of rounds fired. One notable instance was at Dek Sarak, when 28,000 rounds were expended on 50 killed at ranges under 400 yards. Two hundred of the enemy were really killed that day, but 100 were shot down by a single volley from one company at about 100 yards range, and another 50 were killed in a cavalry charge. All this firing, except the one volley, was a purely independent fire. There was no fire discipline, direction, or control. The result was that the whole of the ammunition with the force was fired away, and the troops had to retire to camp—followed by the enemy the whole way.

“When our troops were shut up in Sherpur, on several occasions when independent firing began it increased to such a pitch that neither bugle nor voice could be heard, and the men did not stop until they had fired the last round they had on them. The enemy did not mind this fire; but when volley-firing had to be resorted to in the end, in order to maintain control of the men, the enemy were invariably seen seeking for a safer position.

“At the disaster of Maiwand, the uncontrolled independent fire of our troops failed to stop the onrush of the closed masses of the enemy, and had no effect on their artillery.

“In Egypt, in 1882, complaints invariably came, after every action, of the bad shooting of our troops. And why? Because it was independent, unconcentrated fire.”

Hohenlohe, in his letters on infantry, gives a spirited account of an attack made at Sedan by about 5,000 French on two companies of German troops. The French columns were subjected to a heavy artillery fire, but not stopped by it, and as they neared the German infantry they were masked by the latter. The German infantry, outnumbered at least 10 to 1, by slow and concentrated fire utterly destroyed the French attack, the few who endeavored to retreat falling before the controlled and steady fire of the German rifles.

Result of Comparison.—"However great may be the difficulty of maintaining control of fire, it will be amply repaid by its advantages—economy of ammunition, proper adjustment of the sights, and direction and concentration of the fire on the proper objectives."

The Italian regulations say: "The maximum effect of fire can only be obtained so long as the fire can be concentrated on the point which seems most important, and in the shortest time possible"—which requires controlled fire.

"In war it is very important not to waste ammunition; the fire ought to cease as soon as the objective disappears or offers too small a surface. The officers ought therefore to be masters of it, and for this reason fire by command has the preference." (C. C. J.)

"Controlled fire preserves us from the thoughtless firing of the soldier who believes he has acquitted his conscience by firing all his cartridges, without considering the lack of results from such a badly-organized fire." (Okounef.)

"In an uncontrolled fire, soldiers do not adjust their sights properly ; they fire hurriedly ; the smoke prevents their seeing before them ; the noise of the firing drowns the voice of the leaders, and even the sound of bugles ; and thus the men continue to uselessly waste their ammunition." (D'Azemar.)

"The education of the soldier should be directed towards a severe fire discipline, that a commander may, in the combat, obtain the full advantage of the rifle, and be able to pass suddenly from the defensive to the offensive when the opportune moment, always short, presents itself."

Control of fire ought to be maintained at least up to the limit of efficacious individual fire. Inside of this distance it will hardly be possible to maintain it ; but the better one's own troops and the worse the enemy's, the shorter the distance.

Conclusion.—The "kind of fire to be used," then, is some one of the forms of controlled fire, as long as this is practicable, and every means should be adopted which increases the possibility of control.

Methods of Executing Controlled Fire.

The pauses in controlled fire should be made by large units, ceasing their fire for a sufficient time. If the pauses are only made by small groups, these will cease and reopen the fire irregularly, there will be no real pause for orders to be transmitted or the smoke to dissipate, and the effect on the enemy will be that of a continuous fire, without the moral effect of suddenness.

There are four ways in which controlled fire can be executed :

1. Mass firing, in which each man fires at his own convenience as to time, a stated number of rounds at the named object, with the required elevation.* This produces, at intervals, a rain of bullets, continuous while it lasts.

2. Volley-firing, in which all the men fire together by command, with the required elevation, at the named object. This causes the mass of bullets to fall suddenly and together.

3. In some parts of the German army, the men have been taught to deliver at the longer ranges, without ceasing to advance, a mass fire of a stated number of rounds; each man of a group or other designated unit successively running to the front to fire, and then waiting for the line to come up. At the short ranges, the advance is made by rushes at full speed and without firing. This method has the great disadvantage that it lacks the element of suddenness, the moral effect of which is so valuable.

4. If the firing-line is divided into definite and recognized groups of moderate size, group volleys may be fired at ranges where volleys by larger bodies would be entirely impracticable.

Use of Volleys.—Volleys can be fired by large bodies of troops only when in close order. The body firing should not exceed 100 men (about a company), and the orders should be given with sufficient deliberation to give the men time for careful aiming. Not more than four successive volleys ought to be

*In our Drill Regulations this is called "Fire with counted cartridges."

fired without a pause of some length, to prevent its degenerating into an independent fire.

The moral effect of volleys is very great. They should be employed as long as possible. On the defensive they are especially valuable. Indeed, the French Regulations go as far as to speak of them as possible and eminently advantageous even at the last moment, when the assailants dash forward to the assault.

On the offensive, volleys belong to the preparatory or long-range stage of the action. They should not be used by the troops who are actually to make the assault, but by those specially detailed for the purpose, as already referred to.

It has been asserted by some that war experience has shown volleys to be impracticable in action. Von Boguslawski is particularly emphatic on this point. He says:

“The cases in which volleys were fired in a downright infantry engagement could probably be easily counted; the few cases in which the use of volleys can be well authenticated were when the French were surprised. Neither French nor Germans ever succeeded in pushing forward battalions or companies to fire volleys. Even when on the defensive, to which, according to theory, volley-firing is particularly applicable, it could so seldom be employed that the exceptions prove the rule. Even behind cover, field works, barricades, etc., the fire of dense clouds of skirmishers was preferred to bringing forward bodies in close order to fire volleys.”

This is certainly high authority, but in this war there were

many extraneous circumstances which militated against the proper employment of volleys. The fire discipline now thought necessary for European troops did not then exist, nor the definite fire tactics which they now employ. The armies had great numbers of young troops and reserve men, and volleys were attempted by large bodies, such as companies 200 strong. Again, Von Boguslawski evidently speaks only of volleys by troops in close order, and there seems to be no record of any attempt to use volleys fired by comparatively small bodies, say 50 men, deployed at small intervals. Yet such attempts would seem to promise both feasibility and effect.

Volleys have an especial value for repelling night attacks, in which troops are very liable to get out of hand from not being able to see what is going on.

Mass-Firing.—At ranges where volleys can no longer be fired, control can still be maintained by mass-firing. In this the number of rounds is fixed beforehand, and the fire ceases, without further command, as soon as the number is fired. It should not exceed three or four at most, as men under fire cannot be expected to keep count of a greater number. The number must be strictly limited and adhered to, or the pauses will be lost.

Von Boguslawski doubts the possibility of controlling mass fire by this means. He thinks that in the excitement of battle the men will not attend to the order for limiting the number of rounds, and that a specially shrill whistle, by which the men have been drilled, is the only thing that will stop the fire at

such moments. The Germans believe strongly in the whistle. They train their men to cease firing as soon as they hear it, and turn their heads toward the leaders to look for instructions. In England it has been ordered that all officers shall wear whistles at parades for drill.

Mass-firing should be carefully controlled to prevent its degenerating into uncontrolled fire—a result which will inevitably occur soon enough, and which should be postponed as long as possible. Its moral effect is not so great as that of volleys, and it increases the difficulty of insuring the proper regulation and alteration of the sights; nor can the strike of the bullets be observed, by which to correct the elevations.

Comparative Accuracy.—The French and Germans consider mass- and volley-firing practically equal in accuracy in the field. In our service the skirmish practice-firing of the company is almost exactly the same as mass-firing, and the distances, theoretically unknown, are really known, so that the results may fairly be compared with those of the volley-firing. The average results of the latter are nearly double those of the former—another reason for using volleys as long as possible.

Group Volleys.—But volleys cannot be fired by large bodies of troops in extended order; and when deployment becomes inevitable, mass-firing must be resorted to, unless some plan is adopted for firing volleys in smaller bodies. This may be done by dividing the firing-line into groups under recognized leaders, and using group volleys under the supervision thus made possible. These groups will be described in the next chapter.

CHAPTER 11.—THE FIRE UNIT.

Transmission of Command.—Controlled fire cannot be properly executed unless the men are divided into organized groups, each under a leader. The only means by which, in the noise and excitement of battle, the will of one man can be clearly conveyed to a large number, and understood and executed by them, must be found in a proper system of communication through subordinate commanders, the lowest of these giving the orders to a few men who are within easy reach of his eye and voice.

General Skobeleff adds to the instructions already quoted: "That is why I cannot urge too strongly on commanders to have the fire of their men under control, and in order that this grand maxim may be a reality and not merely empty words, it is necessary that the commander of every unit should know how to make the hearts of his soldiers beat in unison with that of his own before the battle.

He must have his troops completely in hand at the critical moment of action, and they must be in his hands an instrument which serves him to express with supreme energy his thoughts, will and feelings."

Limit of Personal Control.—To realize the full value of fire it must be concentrated. But a single officer's control cannot be felt over a wide front in action, and hence the firing-line

must be divided into groups of suitable size, and these groups, and not the individual men, considered as the fire units.

The power of directing the fire depends more on the front occupied than on the strength of the unit in men. The longest line that can be properly commanded by one man, even at a distance from the enemy, is about 50 paces front, corresponding to a strength of about fifty men in single rank, or 100 in double rank.

In order to assure unity of direction and concentration of fire, we should retain this maximum unit under one command as long as possible. But as the enemy is approached the difficulties of control increase, and the control is thrown successively into the hands of the commanders of smaller subdivisions, until it rests in those of the leaders of the groups, which are the real fire units, the direction remaining with the company commander, and being exercised through the platoon and section commanders.

Strength of Groups.—These groups should be large enough to prevent the control of the fire from falling into the hands of inexperienced leaders, and small enough to bring each man directly under the eye of his leader. Under a close fire, one man cannot look after more than 16 at most, and smaller groups than 8 men would split up the command too much; hence these may be considered the maximum and minimum respectively. The latter is prescribed as the strength of the group in our service, to which the name "squad" has been given.

Though his group organization has not yet been tried in war, it has received the general approval of experienced soldiers

It furnishes an unbroken chain of military authority, from the commander of the forces to the man who holds the rifle. Thus, and thus only, can the purposes of the commander be carried out with full vigor, the efforts of all be directed to a common end, the waste of ammunition be reduced to a minimum, and the full tactical effect of the material results be obtained.

Concentration of Fire.—Each of these groups should be looked upon as one of the guns in a battery, and the fundamental rule of artillery action—the concentration of fire on the important point—be applied to the infantry as well. When the shortening range makes this no longer possible, both artillery and infantry fire directly to the front, independently and rapidly, and then only.

Mixing of Units.—The group organization also gives the means of minimizing the evils arising from the mixing of the larger units in the firing-line. Many attempts have been made to avoid this mixing by arranging the companies, battalions, etc., but none have been successful, or can be without incurring the greater evil of loss of unity of direction. The larger units will intermix as reinforcements are brought into the firing-line, and the best we can do is to bring up these new troops in groups, and between the groups left of those who preceded them.

Reinforcing.—Officers and group leaders should be on the lookout to see when reinforcements are approaching, and cause their groups to close in on the directing file. The leaders of

the fresh groups look to the nearest officer in the firing-line for orders.

Breaking Up of Groups.—As the range decreases and the enemy's fire grows more effective, the original groups will be broken up from losses, from the inevitable drifting of the men to the right or left, and from the unavoidable mixing of the larger units.

Captain Layman says: (Frontal attack of infantry.) "In an offensive engagement, within the short ranges, there are no longer any decided (*i. e.*, organized) groups. Here and there in the vicissitudes of the fight, new groups are formed."

Remedy.—We must provide for this by training the men in peace, to form new groups when their own are broken up, and, when their leaders are lost, to place themselves voluntarily under the nearest leader. Every man should be taught the uselessness of independent action, except at the shortest ranges, and the value of combined action at all ranges.

Colonel Hale has pointed out the fact that the narrow basis of personal and individual attachment "is all very well in theory, but utterly vicious in practice—whereas we ought to seek to establish in the confusion of battle, a feeling of universal camaraderie; soldiers under fire should feel that it does not matter two straws whether it is their own personal comrade and friend whom they are to assist and to whom they can turn for help, but that so long as the man near them is one of their own army, it is him they must help, it is he that will help them. They will not find their own company officers

there; these will have fallen, their battalion will be led by a company officer, their sergeants will be leading companies, and in their difficulties they must follow the nearest leader."

Commanders of platoons and sections must be on the alert to appoint fresh group leaders in place of those who are killed or too badly wounded to continue their duties.

Thus, having organized groups to be used as long as possible, we must thoroughly train the men, in peace, when the groups are broken up, to form new ones under the nearest leader, to whatever regiment or corps he may belong, in order that a controlled and collective fire may be possible, and the greatest power of command and direction of the efforts of all to one purpose may be obtained. The importance of this cannot be exaggerated. The common experience of our daily lives shows the influence which habit has on the actions of men. Even at moments of great mental strain, they may be made to follow, by the means to which they are accustomed, the habits which have been instilled into them.

This system, happily adopted in our drill regulations, should be thoroughly practiced by our troops.

It was at one time thought that the extended order which the modern rifle necessitates would require less training for troops than formerly, and the rapidity of fire of modern arms would make partially trained and imperfectly disciplined volunteers more reliable; but experience in war has shown the exact opposite to be the case, and that discipline, direction and control

are more important than ever. These depend on proper training in peace, for it is in peace that we must teach men what they are to do in war, and we need not be surprised if lack of such training or error in its direction bear their natural fruit of failure when the strain comes.

CHAPTER 12.—SUPPLY OF AMMUNITION IN THE FIELD.

A Vital Question.—In spite of every effort to economize, the consumption of cartridges with the modern rifle will be very great. Von Scherff refers to a full supply of ammunition and its certain and sufficient replenishment as a condition for the existence of infantry, which must be satisfied. The question of supply and replenishment is therefore one of vital importance. Each soldier must have at his disposal a sufficient number of cartridges to do the work required of him. This supply is carried partly by the soldier himself, and partly by wagons, carts, or pack animals, which should be so distributed as to form a complete chain from the stationary magazine in rear to the combatant in front. This includes some means for bringing the ammunition from the nearest wagon, etc., to the soldier in action.

Examples of Number Expended.—In the manœuvres of the XIth German Army Corps at Cassel, in 1878, the principles of fire tactics were carried out, including long-range fire. An average of 100 to 120 rounds per man was fired during exercises which lasted only four or five hours, and during which the greatest coolness and economy were observed. If we allow an increase of one-half, due to the excitement of the battle, this gives some 180 rounds per man.

Experiments made at the camp at Chalons, in 1878, showed that, where long-range fire was to be employed, each man at the beginning of an action should have at least 100 cartridges, exclusive of any to be supplied during the fight.

The Russians say that each soldier should have at least 120 rounds on him, on entry into action, to prevent any chance of his running short of ammunition.

The retirement of the French right, which decided the battle of Gravelotte, is said to have been wholly due to the lack of ammunition, which should have been and was not supplied by their trains.

Increasing the Number Carried by the Soldier.—An increase in the number of cartridges to be carried by the foot soldier, without corresponding decrease in weight of the rest of his equipment, is limited by the fatigue which such an increase in his load will cause him. We ought to find means both to give the soldier as many rounds as possible when he goes into action, and to supply expended cartridges during the fight.

A number of experiments have been made in France, to see if it was not possible to reduce the weight of the soldier's clothing and equipment, so as to increase the food and ammunition he can carry. As a result, a French infantry soldier now has to carry his rifle and bayonet (11 lbs.), ammunition (7.5 lbs.), equipment (1.5 lbs.), change of clothing (12 lbs.), three days' food (7 lbs.), and camp equipment (10 lbs.); total, 49 lbs. The infantry soldier in our service, with three days' rations, carries 51.75 lbs.

If our infantry are to carry all the impedimenta with which they are supplied, they cannot be expected to carry more than 7.5 lbs. of ammunition. Major Mayne considers it a serious question, in view of the great value of mobility in war, whether the foot soldier should be made to carry all that he does. In the Franco-German war, many of the Germans were given twice their normal allowance of wagons, to carry the baggage of the men and fit them to get easily over long distances.

On the defensive the ammunition may be replaced with comparative ease, as supplies can be brought up close to the stationary firing-line and distributed to the men before the enemy approaches. The men can prepare little receptacles for their ammunition, so as to facilitate loading. On the offensive, the replenishment of ammunition, comparatively easy at long ranges, becomes very difficult as the position is approached.

A System of Supply Described.—The principles of ammunition supply are substantially the same in all the European armies, and the description of one will answer all our purposes. We have no established system in our service, which is much to be regretted.

The following description from Major Mayne, gives a good example of a system of ammunition supply :

In the French army the ammunition is carried partly—

1. By the soldier.
2. By battalion ammunition wagon,
3. By ammunition parks,

Each soldier carries 78 rounds on him—36 in his pouches and 42 in his knapsack.

Each battalion has told off to it a four-horse ammunition wagon, containing 18,144 cartridges, or 18.1 rounds per man. These wagons consist of a fore and a hind part, connected by a trail (like that of a gun) fixed to the hind part and hooking on to the fore part. Three removable chests are placed on this frame-work, one on the fore part and two on the hind part. The cartridges are packed into the chests in 36 canvas bundles with handles; each of these bundles contains 28 packets of 6 cartridges. Thus each chest contains 36 bundles, or 1,008 packets, or 6,048 cartridges. A chest can be filled or emptied in five minutes by three men—one to load or unload, and two to hand up or take away the bundles. Each wagon also carries 12 canvas wallets or bags for the transport of the cartridges from the wagons to the soldiers.

These wagons are reported to have proved very successful. They are stated to combine the conditions of solidity and mobility desirable, being easily drawn along the most difficult roads, across streams, up steep slopes, and, in fact, capable of being taken wherever it is possible for a wagon to pass; while they have always been able to be kept a convenient distance from the fighting line, except in some special cases, where the operations took place in such close or cut-up country that it would have been impossible to move even the lightest cart through it. But large operations are rarely carried out in such

countries, and in such cases it is always necessary to provide a special system of supply by means of pack-animals.

The drivers of the battalion wagons are men taken from the battalion, wear the same uniform, and are exercised in driving wagons, either with the artillery or the military transport department, in the garrisons in which they are.

The army corps ammunition park is in the charge of the artillery, and is divided into two echelons. The first echelon furnishes a first supply to the infantry and batteries of the army corps. It is divided into six sections. The first two sections (*i. e.*, one for each of the two divisions of the army corps) are told off for the transport of the infantry ammunition, and carry 46.4 cartridges per man; the remaining four sections are specially told off for the transport of the artillery ammunition — *i. e.*, one section for the artillery of each of the two divisions, and two sections for the corps artillery.

Each of the two sections (for infantry ammunition) of the first echelon of the army corps park, consists of:

- 32 4-horsed infantry ammunition wagons.
- 1 4-horsed forge wagon.
- 1 6-horsed forage wagon.
- 3 2-horsed provision wagons.
- 1 4-horsed battery wagon.

Total, 38 wagons in a section.

The ammunition wagons are like those already described, and each contains 18,144 cartridges, but in each section the fore

chest of one wagon is told off for revolver cartridges, and thus the supply carried by each section of infantry ammunition is 574,560 rifle cartridges and 11,285 revolver cartridges.

The second echelon of the army corps park carries 33 cartridges for each infantry soldier, and artillery ammunition for the replenishing of the first echelon. It carries besides some spare articles, and the necessary stores for the repairs of artillery.

There is no special reserve of cartridges for the other arms besides infantry, but they can draw on the infantry reserve when necessary. However, for the independent cavalry divisions, a reserve of three wagons per division is made, in which the fore chest of each wagon carries revolver cartridges, and the hind chest carbine cartridges.

Behind the army corps park comes the army park, composed of five similar echelons for the intermediate supply between the stationary magazines and the army corps parks.

Other nations have systems somewhat similar. The number of cartridges supposed to be carried is shown in the table on the following page.

These numbers are based on the battalion at full strength, and if we consider the number of absentees from sickness, wounds and death, and the fact that the cartridges of the killed and wounded should always be used, each man may be supposed to have at his disposal from 120 to 150 rounds, with a further supply ready for him at the end of the day.

METHOD BY WHICH AMMUNITION IS CARRIED.	SUPPLY PER MAN.					
	Ger- many.	France.	Aus- tria.	Rus- sia.	Eng- land.	United States.
By the men.....	100.0	78.0	100	84	70	90
In battalion wagons	38.4	18.1	35	48	30	.....
Total first supply for fighting line	138.4	96.1	135	132	100	.....
In first line of ammuni- tion columns.....	29.5	46.4	48	52	40	.....
Total supply for field of battle	168.0	142.5	183	184	140	.....
In second line of ammuni- tion columns (not avail- able for battle).....	29.5	33.0	32	13	30	.....

Rules for Replenishing Expended Ammunition.

The next question is, how to get the cartridges to the men, the most difficult part of the problem.

Continuation of French System.—In a French regiment of three battalions, a chief artificer, mounted, is charged with the general superintendence of all the regimental wagons; a non-commissioned officer and two men are also assigned to each battalion wagon, who mount only when it is moving rapidly.

On the field of battle, wagons are kept together regimentally; only exceptionally do they accompany their respective battal-

ions. Their position is assigned them by the commander of the regiment, and they are, as far as possible, to be concealed from the enemy's view. They should not be more than 1100 yards from the firing-line, and this distance is to be decreased when cover is available. At critical moments the commanding officer may direct them to be moved up rapidly to the firing-line. Their position is marked by day by a yellow flag, placed well to a flank, so as not to afford a target to the enemy, and at night by a yellow light.

One or more extra packets of ammunition are to be issued to the men before they join the firing-line, and every favorable moment, every pause in the fight, every slackening of the enemy's fire, &c., is to be seized for renewing the supply. In important defensive positions, depots of ammunition are to be established along the line and the battalion wagons may even be posted there, if cover can be obtained for them.

The cartridges of the killed and wounded are collected for distribution among the combatants; any in excess, after completing the individual supply, are placed in the baggage wagons; cartridges are returned to the ammunition parks only when there is no means of carrying them with the corps.

It is absolutely forbidden to send men back from the front for ammunition; it is to be brought from the wagons to the firing-line by men detailed from the reserve. Each of the men so detailed carries a double wallet, twelve of which are in each wagon. In this, 56 packets (336 cartridges) are placed. The weight of the wallet, thus loaded, is about 37 lbs., and it is car-

ried slung over the shoulder, one pocket in front and the other behind. The bearers distribute the ammunition among the men firing, and return to the wagons for a fresh supply when the wallets are empty.

If a battalion wagon has to supply troops other than those to which it is attached, the non-commissioned officer in charge makes the issue on a voucher or memorandum, showing to what troops issued, amount issued, and the rank and signature of the person making the requisition. As a rule, when the battalion wagons are grouped together, one is emptied before any issue is made from the others.

The chief artificer, being responsible for the replenishment of his supply, must know where the nearest ammunition section is posted, and should take care that the non-commissioned officers in charge of wagons are also informed of its position. When a wagon is nearly emptied, the remaining cartridges are placed in the wallets, and the chief artificer sends to the ammunition section for a full wagon. This is brought up and its contents transferred to the empty battalion wagon, the non-commissioned officer in charge giving a receipt. The empty wagon then returns to the ammunition section from which it came.

The first echelon of the corps park ought to be near enough to the troops to furnish them without delay the ammunition they require. Its position will be about 1600 yards in rear of the firing-line, the sections being placed as near the troops to which they are allotted as the roads will permit. They must leave

the roads clear as soon as the necessary openings and ramps are made. Their arrival is to be reported as soon as possible to the commanders of divisional and corps artillery. By day, each infantry section is indicated by a yellow flag, and each artillery section by a blue flag; at night by lamps of the same color.

After an action, the ammunition sections are directed on points designated as "distribution centers," to which the empty wagons are sent in groups, under an officer, to replenish their supply. They are supplied by moving ammunition from one wagon to another, and not by exchange of wagons, which is to be as rare as possible.

Cavalry divisions are to be supplied by any section applied to. Every demand for ammunition is to be satisfied, even if it comes from a strange corps.

As a rule, the second echelon of the corps park is to be kept a day's march in rear of the troops, but during a battle it is brought nearer to the first echelon. Its sections always march together, and form a "distribution center," at which the empty wagons of the first echelon are refilled. The empty wagons of the second echelon are sent in large groups to the nearest army park, the position of which should have been previously made known, by the commander of the corps artillery, to the commander of the second echelon. The commanders of the echelons of the army park should also be informed of the position of the second echelon of the corps park, so as to put themselves in communication with it.

The second echelon of the corps park must satisfy all demands for ammunition, by whomsoever made. Any commander in an independent position can send a written requisition (even in pencil) for ammunition. Even if a demand is made without a written request, it must be granted, but a receipt is taken.

After a battle, "states" are sent in, showing the amount of ammunition required to reestablish the normal supply. Similar "states" are sent in every five days.

SUGGESTIONS FROM OTHER ARMIES.

Austrian.—In the Austrian army, when an engagement is expected, each man is to be given, before the march begins or during a halt, 20 extra rounds. The ammunition wagons always accompany the troops. During an action they remain, as a rule, near their battalions. If any companies are detached, they are accompanied by their wagons.

As soon as the combat has begun, the ammunition wagons advance, without waiting for orders, close to the reserve of their battalions, and follow its movements, avoiding exposure as far as possible.

On the offensive, as soon as the battalion forms for battle, the leading companies detail from six to eight men — if possible, from among the buglers, drummers, and pioneers—who go to the wagons under a non-commissioned officer. Each takes a haversack containing 300 or 400 cartridges, which they carry to their companies.

Further supplies are usually carried to the firing-line by the troops reinforcing it. They may be carried by small detachments, sent forward under a non-commissioned officer, who remain with the firing-line.

German.—The Germans expect the battalion wagons to be within 900 yards of the battalion in action. Their regulations provide that the commander of the first ammunition echelon can if he thinks proper, and must if he is ordered, send some of his wagons to those points where heavy fire shows that ammunition is being rapidly expended, so that an empty wagon may be quickly replaced by a full one, while it goes to the first echelon to be refilled.

Russian.—The Russians have a system of replenishment by successive demands on the troops in rear. The commander of any troops who require ammunition sends two or three men to the commanders of the units next in rear. These make their men give up half the ammunition they carry, and also furnish enough men to carry it to the troops who need it. The carriers, after distributing the ammunition, remain with the line to which they were sent.

The English Regulations contain a similar provision.

The Russians also provide for an issue of extra cartridges to the troops before the fight begins.

General Considerations.—In the latter stages of the fight when the firing-line is within say 600 yards of the enemy, it cannot be supplied with ammunition by carriers. If a man attempts to carry 400 rounds, weighing some 35 lbs., his total

load will be about 90 lbs., and he simply cannot carry his burden to the firing-line, a distance of something near a mile, most of it under fire. Yet this would give to a company 100 strong only four rounds per man, which would not last 30 seconds.

An official work on the "Armed Strength of Russia" states that the cartridges are to be sent forward "in bags secured to hooks on the harness of the outside horses."

The "Revue Militaire de l'Etranger" says that in Germany "the supply of ammunition to the firing-line is no longer to be carried out by means of carriers. This method has been recognized as completely inefficacious, and the two leading draft horses of the battalion wagon will be used instead. Each horse will carry two boxes of 1000 rounds each." These horses will only go as far as the supports of the firing-line, who will carry the cartridges to the firers.

An excellent plan has been devised by an officer of our own service* for carrying ammunition on pack animals, which is easily applicable to this purpose.

Four boxes of special construction, weighing 55 lbs., and containing 500 rounds each, are to be carried by each horse. The boxes are not costly, and they have the very great advantage of opening easily, without taking them off the horse, if desired, and of a contrivance by which the packets of cartridges are lifted partly out of the box, so as to be readily seized by the

* Lieut. Robert K. Evans, of the Twelfth Infantry.

hand.* They have handles by which they may be carried forward by men when it is considered unsafe to send the horse nearer to the front.

The difficulty of supply after the fight has commenced makes it important to issue extra cartridges to the men before it begins.

The infantry which comes first into action cannot perform the duty required of it with the 90 rounds which they carry in our service, and it will be almost impossible to supply them with any large quantity, at least over open ground.

Long-range fire will certainly be employed in future wars,† and for this reason each soldier should have at least 120 rounds even when the fire discipline and the fire tactics employed are best; and the surest means of getting it to them is to issue it before the battle.

Management of Ammunition Wagons.—The manœuvring and placing of the battalion wagons is an important point. All nations detail the drivers of these wagons from the men of the battalion to which they are assigned. Experience has shown that only by employing drivers who know the battalion and feel an interest in it, can the proper manœuvring of the wagons be assured. These wagons, well horsed and driven, will become, not a detriment, but an advantage.

An intelligent non-commissioned officer is indispensable for

*The box in which ammunition is now packed would make it, on the battle-field, about as accessible as if it were in Alaska.

† With or without fire discipline.

proper guidance of the battalion wagons, for superintending the issue of ammunition, and the replenishing of empty wagons. He should be practiced in his work in peace, and detailed for it, for the first time, in war.

A number of men in each battalion should be taught in peace to look after ammunition. These should be the men who load and unload the wagons and give the ammunition to the carriers; one or two should be permanently assigned to each wagon.

On the march the battalion wagons may follow their battalions or be grouped in rear of the brigade. No battalion should ever go into action without its wagon. From the nature of the case, great latitude must be allowed in the placing of these wagons on the field of battle, but they should not be more than 1000 or 1100 yards from the firing-line, sheltered as much as possible. In the majority of cases, (not invariably, by any means,) the wagon should move with the battalion reserve. As the other companies of the battalion advance toward the enemy, the reserve will be employed to cover the advance by volleys at long range if suitable positions can be found. This will entail a considerable expenditure of ammunition, which the wagon should be ready to replenish.

The wagon may be in some cases brought up to the firing-line—as, for instance, when a position or advanced post has been captured, and must be held at all costs against a counter attack.

All infantry ammunition wagons should be of the same pat-

tern, so as to be interchangeable. If the wagons for infantry and artillery are alike, they should be painted of different colors, and flags and lamps of different colors should be used to designate their positions.

It is rather difficult to understand, if ammunition wagons are all of the same pattern, why empty wagons should be sent to the rear, refilled there, and then sent back. When a wagon is nearly empty, a full one ought to be sent to replace it, the two exchanging teams and drivers. If wagons are to go to the rear for replenishment and return to their battalions, there is danger that any movement of the battalion may cause the wagon to be lost for that day.

Every ammunition wagon ought to supply any troops which ask for ammunition, provided only that such troops are engaged.

The difficulty of replenishing ammunition furnishes another potent reason for careful training in a rigid fire discipline. Infantry in attack should reserve their fire until they come within effective range. The advance should be well prepared, and covered by concentrated artillery fire, and also, if good positions can be found, by infantry firing at long range where it can be kept supplied with fresh ammunition.

In battles which last several days, the ammunition is replenished at night. A regular and plentiful supply of ammunition may offset a superiority of numbers on the part of an enemy whose system of supply is defective.

Enough has been said to indicate the necessity for arranging

a proper system of ammunition supply. "It cannot be too strongly insisted on," says Mayne, "that troops should be frequently practiced in peace-time at being supplied with ammunition during an attack, for this service can only be assured by the aid of men perfectly accustomed to duties of this kind." This, along with other matters, is entirely unprovided for in our country.

CHAPTER 13.—RAPIDITY OF FIRE—MAGAZINE RIFLES.

Advantage of Rapidity.—The comparison of rifles by their range, flatness of trajectory, and accuracy, only, is not sufficient. The value of a fire depends not only on its possible destructive effect, but also on the promptitude with which that effect is produced; hence rapidity of fire is one of the requisites of the military rifle.

How Obtained.—But here we must make a careful distinction between the methods by which this may be produced. It is not really rapidity of *fire* which should be sought, but rapidity of loading, restraining any tendency to haste in aiming and firing. We must be careful to look on the breech-loading rifle, not as a rapid-firing, but as a rapid-loading arm.

How Measured.—Rapidity of fire is measured by the number of shots fired per man per minute. It may be found for any body of troops by dividing the number of shots fired by the product of the number of firers and the time of firing in minutes; thus, if 100 men fire 700 shots in 1.25 minutes, the rapidity of fire is $\frac{700}{100 \times 1.25}$, or 5.6.

Rapidity of effect is measured by the number of hits per man per minute, on the given target. It is found as above, by dividing the number of hits by the product of the number of

firers and the time of firing; thus, if 100 men make 150 hits in 1.25 minutes, the rapidity of effect will be $\frac{150}{1.25}$, or 1.2.

Rapidity and Effect.—As rapidity of fire increases, a point is soon reached, beyond which the *percentages* of hits decrease. "A fire of 8 to 10 shots per minute always gave a very superior useful effect to that which expended 16 to 18 cartridges in the same time." The ratio of decrease is, of course, very variable, but up to that point at which carelessness or hurry in aiming causes an excessive decrease in the percentages, the *whole number* of hits may increase. Thus, suppose an increase in the number of shots, in the example above, from 700, with a percentage of 21.4 (150 hits), to 1000, causes a decrease of only 1.4 per cent., leaving 20 as the percentage: the whole number of hits for the same time will be 200; while if the same increase in the number of shots reduced the percentage to 10, there would be but 100 hits. It may be said, however, that unless the men are well trained, any considerable increase in rapidity of fire entails so great a loss in the percentage of hits, and the men are likely to be so eager to fire rapidly, that our efforts will usually be needed to restrain them. A very rapid fire should only be tolerated at the very short ranges, at which the utmost we can expect of the men is that they should hold the rifles horizontal.

Duration of Rapid Fire.—A very rapid fire can be kept up only for a short time. Colonel Campe says: "The rapid fire at the final stage of the attack) ought not to last more than five minutes; 40 or 50 well-aimed shots fired by each man

ought to suffice, especially when the artillery has prepared the attack and shaken the enemy. If the fire lasts longer, the men fire badly, and finally the fire slackens. The moral effect that one wishes to produce on the enemy diminishes or vanishes, and the enemy then has time to bring up reinforcements to the threatened point. On the other hand, the increasing ardor that the offensive movement, aided by the fire, has given to the men, dies out by degrees. It is necessary, therefore, to move forward at the end of five minutes."

Von Scherff is of the same opinion. "The physiological effect of a rapid fire on the nervous system of the combatants is such that at the end of a very short time, which cannot reasonably last more than five minutes, the troops on the offensive will either dash forward or retire."

Von Boguslawski says: "From the lessons of the late war, a rapid, independent fire from both sides cannot well last more than five minutes."

The Belgian experiments of 1881 and 1883 indicate four minutes as the greatest time during which this rapid fire can be kept up, when the men are fresh and have not been firing before. If the men are already fatigued, and the rifle-barrels already heated, this time would be reduced to something like three minutes.

Magazine Rifles.—The importance attached to rapidity of fire has led to a general adoption of a magazine rifle as a military arm. Various patterns have been considered or adopted, and at the time of writing a board of officers is examining the

rifles submitted, with a view to the choice of the best pattern for our army. Under these circumstances, a detailed discussion of magazine rifles would be out of place here.*

Comparative Rapidity.—If the magazine when emptied, must be refilled by introducing cartridges, one by one, the rapidity of fire with a magazine rifle will be greater than that with a single loader only until the magazine is emptied; and for the *continuous* firing of a large number of shots such a rifle gives no especial increase of rapidity. In intermittent fire, where the magazines are refilled during the pauses, the fire is much more rapid and correspondingly more valuable, *if properly controlled*.

If the cartridges are so packed and carried that the magazines are refilled at a single motion,† the fire may be more rapid,

*The board has recommended the "Krag-Jorgensen" rifle, which has a curved magazine fixed under and around the breech, in front of the trigger-guard. The magazine holds five cartridges, and has a "cut-off," by means of which the rifle may be used as a single loader. The cartridges are introduced on the right, moved from right to left by a "cartridge-guide," and enter the chamber from the left.

The magazine is very quickly loaded, either by using a movable "loader," or by pouring in the cartridges from the palm of the hand; they fall into their proper places under the action of the "cartridge-guide."

The cartridges being placed in a single semi-circle around the breech, the magazine does not interfere with the fire kneeling or lying down.

†As may be done with the Krag-Jorgensen. This rifle, then, gives the double advantage of rapid intermittent fire at medium ranges, and rapid continuous fire at the decisive moment.

whether it be continuous or intermittent, making control still more necessary, in order to prevent the waste of ammunition which lack of it would cause.

Time for Their Use.—The idea has been entertained, especially in England, that the magazine rifle should be used as such only for short-range fire. This is a misconception of the true value of rapidity of fire. Troops in battle will have favorable objects to fire on only at intervals, and then only for short spaces of time. During that brief space, immense advantage may be derived from the proper use of an arm which, not requiring reloading, allows many more shots to be fired, each one with as careful an aim as can be taken with any other arm; in short, which requires the soldier only to take time for aiming.

Mere rapidity should never be sought or permitted. The object is not to fire rapidly, but to make as many hits as possible in the time allowed, and officers and group leaders should take every care that each shot is carefully fired.

The moral effect of an efficacious fire increases with the suddenness and rapidity with which its physical effects are produced. The intensity of the fire which the magazine rifle makes it possible to pour in at a favorable moment, *during all stages of a fight*, gives it immense moral value. This does not in any degree contravene the fact that the possession of a weapon which will enable them, at the crisis of the fight, to deliver a terrible fire, will greatly add to the confidence of troops, both in attack and defense.

Pauses in the Fire.—We have already discussed the necessity for pauses in the firing. These will naturally occur in fire with the magazine rifle, when the magazines are to be refilled or changed ; and this rifle, therefore, gives just what we want—an intermittent fire of terrible effect, if the fire discipline be good. But it must be constantly remembered that the necessity for a rigid fire discipline increases with every improvement in the infantry weapon, and that the increased expenditure of ammunition which this intermittent fire, so rapid while it lasts, will entail, increases the importance of certainty and efficiency in its replenishment.

CHAPTER 14.—TACTICAL DEDUCTIONS.

Importance of Tactics.—General Lewal* complains that strategy is studied more than tactics. “However, it is tactics that gains battles, and exercises through them a direct influence on the destiny of states.” Strategy has final victory for its object, and “It is only the gain of the battle which generally justifies the skillful manœuvres carried out by men of genius.” Errors in strategy are condoned or effaced by tactical victory, while the most brilliant strategy is useless when followed by a tactical defeat.

Example.—The battle of Salamanca is an instance in point. The strategical advantage from the beginning of the campaign had been Marmont’s; but the tactical errors of that one day lost him all its fruits.

Few officers are called on to command strategical units, while every officer ought to know how best to use the men, arms and ground at his disposal. Hence tactics should be the principal subject of military study.

Influence of Infantry.—Infantry in battle, as it gains or loses ground, draws with it the other arms. A study of the battle of Koeniggratz gives a striking proof of this fact. The battle was lost to the Austrians, in spite of their superiority in

*“Etudes de Guerre.”

artillery and the vigorous charges of their cavalry, as soon as the infantry was defeated. The German regulations say that "The science of leading infantry consists in the proper employment of their fire." And General Lewal writes: "The manner of disposing infantry on the battle-field, of conducting a cavalry charge, or of placing batteries, is a direct corollary of the effects of fire."

This subject should be approached in the spirit of the following words: "I am not urging that any principle that we have adopted from our experience of the past should be held sacred on that account. The experience on which it is founded must be carefully examined. Whenever we find that the conditions have so changed that the evidence is no longer good, it must be ruthlessly rejected. All modern circumstances must be taken into account. No maxim or tradition should be allowed to stand simply because it was formerly applicable."*

Dissolving Effect of Modern Fire.—The Franco-German war amply demonstrated the dissolving effect of the fire of breech-loading rifles on closed formations, either line or column, at ranges which had theretofore been considered safe. The Prussians had already reduced their columns of attack to the company column of 250 men; but they still regarded skirmishers as destined merely to prepare the way for the final assault of these columns. The first battles of 1870 showed that to advance under fire of the modern rifle some extended order must

* Wellington Prize Essay, 1872.

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be adopted. The extended line rose from its former position of auxiliary, to that of the principal means of attack and defense, and European soldiers learned of necessity what our war might long before have taught them, that successive lines in extended order must be substituted for the old column of attack.

The same lesson was still further impressed by the experience of the Russians in 1877; and General Skobeleff, the most successful leader of that war, gave the result of his experience in the statement that "the only formation in which troops can successfully assault intrenched positions is in successive lines of skirmishers." In the battles of these two wars we read that the final decision was reached not along the whole front, but at the decisive points, with "great swarms, "dense clouds," "thick masses," of skirmishers, from eight to sixteen men deep.

Problem of Attack.—To force a position and drive the enemy out of it, requires the massing of troops in superior numbers as much to-day as it ever did; but modern attack formations seek to solve the problem "how to get these masses up to assaulting distance." It can only be done by sending them over the fire-swept zone in extended order and in successive lines.* Troops in rear are feeders for the firing-line, intended to keep up its fire power, carry forward the wave of attack, and finally, when assaulting distance is by this means reached, to break the enemy's line.

Moment for Reinforcing.—A line of men sent forward in

* This is in fact a substitution of open for closed columns.

attack has a certain limited amount of energy. When this is spent there is a strong tendency to halt. It is at this moment that reinforcements should be at hand to renew the forward movement, until their energy being spent they are in their turn carried on by fresh troops. It would be a fatal error to wait until the front line was defeated before supporting it. When the point of assault has once been determined, the movement should be simultaneous and continuous from front to rear of the attack, and the reserves should be on hand as soon as they are needed.

Attack and Assault—Distinction.—The attack must be general, the assaults local, in order that the assailants may be superior in force at the points of assault. Napoleon's saying, "If you try to be strong everywhere, you are weak everywhere," must never be forgotten. The assault is not the inevitable end of every deployment or fight, even an offensive one. "The offensive is not the assault, and no one has the right to advance and engage his troops without the consent of the commander of the whole force, or they may act contrary to his wishes."

There can be no doubt that this system of attack in successive extended lines will cause a considerable mixing of the larger units. The evils of this are reduced to the lowest practicable point by the group system, already described.

Importance of Fire.—Superiority of fire is the guaranty of victory. "The condition which ought to rank before all others is to obtain a superiority of fire over the enemy. It is neces-

sary to make everything give way to this requirement. The victory is at this price." Napoleon said: "Fire is everything; the rest is of but small account." Lewal writes: "Fire is the great, the principal, and almost the only force in battle; the shock is only a secondary incident. All efforts ought to turn toward the proper employment of fire."

Requisites for Direction.—But mere quantity is not sufficient: the fire must be properly directed, and we must therefore find the means by which direction may be made possible. These means lie in (1) a good organization, which insures the proper transmission of command through all the degrees of the military hierarchy, and permits each individual of an army to be employed according to the will of the commander; (2) in strict discipline, which insures obedience to orders and the suppression of the animal instinct of self-preservation; (3) in sound and constant practice in that which the men must do in battle, which insures their acting as they have been taught to act, in moments of the greatest moral strain. It is an ascertained fact, that men will follow established habits under the greatest excitement.

Battles and Minor Combats.—We must make a distinction between the action of armies in great battles and that of troops in small combats.

1. The front of an independent detachment is limited only by considerations relative to the ground, to the maintenance of proper cohesion, and to the position of the enemy. The rear lines can overlap those in front, and flank attacks can be arranged on the field.

2. With an independent detachment, the artillery can choose its position, and fight on the flanks of the infantry or in intervals of the line.

1. In large battles, most of the troops have a restricted front imposed by the presence of other troops on each side of them. Such troops can move only to the front, and must use the ground lying between them and the enemy. Attacks in flank will be very difficult to arrange on the field, and if made must usually be arranged for beforehand.

2. In great battles, the artillery of an army corps has a front of at least 2,000 yards; hence it must fight on the same ground as the infantry, firing over the heads of the latter.

In minor combats, the attack will derive its greatest chance of success from skillful generalship on the field. In great battles, the prospect of success will chiefly depend on the strategy which precedes them and on the proper use of the physical means of destruction employed.

What Victory Is.—The visible sign of victory to an attacking force is the occupation of the enemy's position. Before this can be done, he must be demoralized by fire or led to use up his ammunition, by which means the final charge of masses is made feasible. The victory will depend less on the actual losses on each side than on the effect of these losses on the determination of the survivors to remain on the defensive, or to advance in the attack. That side which is most determined to effect its object, if it has the means of doing so, will win.

Flank Attacks.—Fire becomes decisive only at short ranges; long-range fire has never won a battle. The problem for the attack is to advance to the decisive ranges without excessive losses. To do so by a purely frontal attack, against a well-posted, disciplined and unshaken enemy, is almost impossible; but it is possible by combining a flank attack with a strong demonstration in front, ready to change into a real attack as soon as the enemy shows any signs of weakness. Flank attacks are now the principal means of offense, and the frontal attack is an auxiliary movement, intended to hold the enemy while the other is in progress.

Our principal consideration is the best method of frontal attack; for an attack on the enemy's flank becomes, as he forms front to meet it, a local front attack, and the defensive should always be looked on merely as a preparation for a subsequent assumption of the offensive. A passive defense can lead to nothing but ultimate defeat.

The Attack Formation.—The attack formation requires, among other things, certain conditions:

1. It should permit the best use to be made of the rifle at all times, and the greatest development of fire to be obtained at the decisive moment.
2. It should present the most difficult target to the enemy's fire.
3. It should allow the best use to be made of such cover as may be available.
4. It should afford the greatest mobility possible.
5. It should give the greatest facility for transmission of orders.

1. Number at First Deployed.—The increase of strength to the defense which comes from the modern rifle has produced an increased necessity for preparation of the attack. The rule which was formerly considered important, of only reinforcing a line of skirmishers little by little, has been found in practice more dangerous and more productive of loss than the extension of a sufficient number from the first. We should therefore give the firing-line from the start, as many rifles as, from the nature of the ground, can be brought effectively into play.

When a serious attack is intended, it should be carried out in the shortest time possible and with the greatest determination. Clearness of design and energy of execution are essential to success; a long drawn out, hesitating attack is fatal to the offensive spirit and to victory.

Deploying sufficient strength from the first gives the moral

effect of the material results obtained, which increases with the concentration of the fire not only in place, but in time. A company firing five shots per man will produce a greater effect on the enemy than a fourth of the same company firing twenty shots per man.

The German principle is to give great density to the firing-line, placing the men almost elbow to elbow. Von Boguslawski gives the number to be deployed as one man to every one-and-one-half paces.

Preparation.—The question may be asked, “How are such lines to live under the accuracy of modern fire, and arrive at assaulting distances?” They cannot do so unless the defenders have been sufficiently demoralized by fire of artillery, or of artillery and infantry combined. Whenever this has not been done, the attack has been brought to a standstill or been driven back by the defenders’ fire. Proper preparation is essential to the possibility of an assault against good troops armed with the modern rifle. Both Germans and Russians suffered terribly when they neglected it.

2. Direction.—Extended formations are necessary, but attack formations cannot be regulated solely with a view to avoid loss. “You cannot make omelets without breaking eggs, and no success can be gained in war without a sacrifice.” Avoiding loss as far as possible, we should chiefly study to inflict it, giving the preference to such formations as best assure the exercise of command, the cohesion of the force, the connection as

well as the reciprocal action of its component parts, and, above all, the vigor of the attack.

3. Cover.—Cover should be used as long as its use does not interfere with the main object—winning the fight. Men should never be permitted to seek cover which hides the enemy from the view, the greater object being to destroy the enemy, not to protect oneself. Battles are not life-saving institutions.

4. Rapidity of Advance.—The best safeguard from an enemy's fire is rapid movement over the fire-swept ground, which reduces the time during which his fire can act and the chance of his finding the ranges with any accuracy. Von Boguslawski says: "It is an established fact that the rapidity of the advance is a great method of reducing the effects of the adversary's fire. All attacks and movements made under fire should be executed at the double. . . ." The greater part of the losses of an attack occur at the halts. The means of reconciling this rapidity of movement with the requirement of superiority of fire is to be found in the subdivision of duties already alluded to; some to keep down the enemy's fire, while others advance to the decisive ranges.

5. Orders.—The transmission of orders can be assured only by dividing the men into groups under their proper leaders, thus preserving an unbroken chain of military succession from the highest to the lowest, and at the same time bringing every man under the eye and command of his immediate superior. The men should be trained to pass orders along the line, to insure

their delivery when the fire is so hot that the officers cannot personally deliver them.

To satisfy the first four of these conditions, troops must be extended, while to satisfy the first and last, they must be in organized groups. This extended order is not an advantage; it is a distinct evil, requiring the most strenuous efforts to counteract, or reduce its effects to a minimum. The method now generally accepted is the group system.

Depth.—Troops once engaged can no longer be moved to the right or left, nor can they be withdrawn and used elsewhere. “Straight to the front—forward,”* is the only word of command suited to the attack, and the only command which is sure of its moral impulse on the soldier.

Every commander ought therefore to use a deep formation, constantly and continuously reinforcing the front line from the rear.

Retreats.—It is, to speak mildly, very doubtful whether troops who have once reached close ranges can retreat at all under the fire of the rifle. “It is possible for the attack to fail, but not for us to go back. The sword cuts, or flies to pieces; the army conquers, or there will be only fragments to collect.”*

This applies both to attacker and defender, when once closely engaged.

Pursuits.—Pursuits are extremely difficult, on account of

the mixing of units of the attacking force, during an energetic advance under fire.

Retreating troops in recent wars have usually been able to retire without serious pursuit, especially when even a small reserve has been held intact. Such a reserve is enabled by the retaining power of the modern rifle to hold its own, for a time, against a disorganized, though victorious enemy.*

Re-forming.—Troops must be re-formed as soon as the first position, or any intermediate position, is carried. They can never know whether there is not a second line of defense in rear, against which a disorganized advance would be stopped, and a first success turned into a defeat. It is only by re-forming promptly that command, cohesion and control can be maintained, the evil of mixing of units reduced to a minimum, and the moral effect of numbers impressed on the men, who are apt to over-estimate their losses. Re-forming also renders the men available for use in other directions, and gets them in hand to meet further efforts of the enemy.

Phases of Attack.—The attack may be divided into four distinct phases: (1) the reconnoissance; (2) the preparation; (3) the execution, including the actual assault; (4) the re-forming after success, or the retreat.

1. The reconnoissance is carried out by the advanced guard, who must, after driving in the enemy's outposts, be extended

*"The second Prussian corps, after Koeniggratz, took six hours to pick out its men and re-form."

over the whole front of the position, to cover their own artillery, and, by drawing the enemy's fire, to discover the extent of his position and the disposition of his front line. During this time they should be well extended.

2. The preparation is then carried out by the artillery, assisted, if necessary, by the infantry.

"We now know what a frontal attack against a position defended with breech-loaders signifies. . . . If we have resolved to undertake this task—in any case the most difficult and sanguinary for which infantry can be employed—the least we can do is to make the most careful preparation, in order to secure the greatest possible chance of success. It is not to be accomplished solely by an impetuous rush forward; the greatest bravery can be wrecked in a fire-zone of 1000 paces. The time spent in making a good disposition and introducing the attack is never lost."

It is important that the troops should be prevented from hurrying into action in fractions, before the whole force is ready to begin the fight, as this only makes them liable to be beaten in detail. The German troops at Gravelotte rushed into action as they arrived on the field, and it is extremely doubtful whether they gained thereby any advantage to counterbalance their enormous losses. "The German commander resolved at all hazards to drive back the French upon Metz, while Marshal Bazaine was bound to hold fast to the only line of communications with the rest of France which still lay open to him. The decisive point of the position, therefore, was St. Privat, on the

extreme French right, by which the last line of communications ran. As the fate of the whole battle naturally turned on the course of events at St. Privat, the desperate fighting and frightful slaughter that took place along the rest of the line was wholly unnecessary, and was willfully brought on by the assailants, rather than caused by irresistible necessity.*

The fights at Borny and at Mars-la-Tours-Vionville were brilliant exceptions to the rule; the French were retiring, and their retreat had to be stopped at all costs by the leading German troops, as they came up, until the main body could arrive and fight the decisive combat.

Long-Range Fire.—Long-range fire makes it necessary to assume the formation for attack at greater distances; thus increasing the difficulty of repairing faults in the original dispositions.

Long-range fire, from specially detailed bodies of infantry, will probably be a prominent factor in the preparation of future attacks. If the defensive position be on the crest of a plateau, an opportunity will be afforded for the skillful employment of the principles of inclined fire, already mentioned.

3. When the preparation is considered complete, the execution should be carried out with all possible vigor.

The execution should be subdivided into the advance and the assault. We have already pointed out that the assault is not the inevitable sequel of the advance. It should be delivered

* "A German General."

only on the order of the commander of the whole force, and when made, should be executed with all the vigor possible, and promptly and vigorously supported. An assault without such support is very likely to fail, and the retirement of the troops who attempted it will cause that of the troops on either side. Military history is full of instances of the failure of half-hearted assaults, in which successive waves of attack were neglected. Among them we may mention the English attack on the Redan at Sevastopol, the Confederate attack at Gettysburg, and the Russian attacks on Plevna.*

Allotment of Attacking Force.—Mayne recommends the following division of the infantry, as a basis for practice, when the reconnoissance is to be made by infantry: one sixth for the reconnoissance (which would be the advanced guard); one or two sixths more for the preparation; three or two sixths more for the execution; and the remaining sixth in reserve.

A line of defense consists of a line of strong points. The troops engaged in the reconnoissance and preparation are extended over the whole front, but the actual assault is confined to these strong points: consequently, an increased proportion of the force is available for the local assaults.

The experience of the last two wars shows that the attack should have, including all arms and reserves, 12 to 14 men per

* "The miserable, doubting, unmilitary policy of small storming parties, on the plea that if we fail we cannot lose many men, causes more mischief, loss and disgrace than any other proceeding in war."—SIR JOHN BURGESS.

yard of front; this includes troops destined for flank attacks. This would give 1 man per yard for the reconnoissance, 2 for the preparation, 5 for the advance, and 10 to 20 for the local assaults. The defense ought to have 7 to 10 men per yard.

During the reconnoissance the troops should be well extended to develop the position; but in the preparation and assault they should be collected in organized bodies, in order to obtain the full effect, material and moral, of their fire, and to preserve control and unity of purpose.

It is curious to note that in spite of all changes of formation which have followed improvements in arms, the total front occupied by armies of equal strength has remained nearly the same.

Gustavus, Marlborough, Frederick, Napoleon, Lee and Von Moltke fought their battles with a number of men per mile substantially as given below:

Gustavus, at Leipsic, 1631.....	nearly 20,000 to the mile.
Marlborough, at Blenheim, 1704	“ 19,000 “ “
Frederick, at Prague, 1757.....	“ 21,000 “ “
Napoleon, at Waterloo, 1815.....	“ 23,000 “ “
Napoleon III, at Solferino, 1859	“ 22,000 “ “
Lee, at Gettysburg, 1863	“ 20,000 “ “
Von Moltke, at Gravelotte, 1871.....	“ 24,000 “ “

Has Deployment Been Carried Too Far?—The experience of the next war will answer the question whether the principle of deployment has not been carried too far in our present theories. The group system has not been tried in battle. If

on trial it proves a success, there is at least an admissible doubt, whether it is wise to provide, in training men, for any deployment of the groups. The advantages of cohesion, control, and direction offered by closed groups should not be thrown away by any dispersion which is not inevitable. Now, the losses of a line of groups will apparently not exceed those of the same force deployed at equal intervals, at ranges beyond 500 yards. At less ranges the thickening of the firing-line by the necessary reinforcements will have filled the intervals, and, as we have stated elsewhere, as the distance grows shorter, the attack will present the appearance of "dense masses," "swarms" of skirmishers. Therefore in a serious attack the deployment of the groups will be operative only at ranges where it causes disadvantage but no advantage.

The deadliness of modern fire, the increased depth which it necessitates in the attack formations, the greater distance at which these formations must be assumed, and the consequent difficulty in correcting any errors which may be made in the earlier stages of the fight, all give a great importance to the character of the normal formation adopted.

Normal Formations.—General Lewal says: "Normal formations have a real absolute value, provided they are adapted to the ground, to the nature and to the moral situation of the troops—the three elements which control the action of every good and skillful tactician."

In addition to the requirements already stated, a normal formation for attack must be capable of variation, without confu-

sion, to suit the various roles which troops may have to play, from the merest demonstration to the most determined assault; and it must enable fractions of a command to be detached in regular tactical units.

Waves of Attack.—Against an intrenched position strongly held, the attack has but one chance of success—the superadded impulse of successive lines. A line which sees another in front of it will move forward to join that line. A line which is overtaken by one from the rear will join it in moving forward; and if the soldiers of both be well trained, these movements will be, within limits, independent of losses.

So long as the firing-line can be reinforced at the proper moment, the forward movement will go on; but when reinforcements are lacking or long delayed, if the vital energy of the first line is expended before assaulting distance is reached, the movement must cease and be converted into disastrous retreat.

Retreat under fire is now so nearly hopeless that the commander should never order an assault until he has caused it to be so prepared that there is good hope of success; and when he does order it, he should make his dispositions to carry it to a successful issue at all costs. The price of success will not be so great as that of failure, and the idea of retreat from an attempted assault should never be entertained.

Number of Lines.—Therefore the disposition for attack ought to include such a number of available reinforcements that a fresh line will always be at hand whenever it is needed.

This number has been stated by Skobelev as "nine at least," and he is certainly entitled to speak with authority.

These successive lines should move together. The duty of each can be made plain before the movement begins. Once begun, there should be no waiting for reinforcements, for at these pauses the fire of the defense becomes deadliest, and the attack suffers most, both physically and morally.

Distance—How Regulated.—The distance between the lines should be regulated solely by the consideration of prompt and timely reinforcement. The fire of the defense, directed on the firing-line of the attack, will be simply chance fire for the troops in its rear. It will cause losses, without doubt, but these are inevitable and indeterminable, and should not form an element in the calculation. It must not be forgotten that the object of the attack is not to avoid loss, but to succeed.

[At the same time, it might be shown that the losses of the lines in rear of the first are not increased by the distances proposed.]

Once committed to the advance, the leading troops should be supported, not in dribblets, but promptly and vigorously. If at any time the firing-line looks back for supports which are not forthcoming, the offensive spirit dies out, the attack is checked, and the recoil of the firing-line will probably carry back with it all the troops in rear. Then the attack must be commenced again, and the probability of success is not increased by the discouragement of the first failure.

If the assault succeeds, the troops who have to carry the posi-

tion are disorganized by their own success, and it becomes immediately necessary to support them against the attempts of the defenders' supports, who will certainly try to retake any position important enough to justify the assault. Hence reserves must be at hand at this moment to take the place of the leading troops, and allow the latter to re-form; while the reserves complete the success.

Detachments.—But the assault is only one of the parts which make up the battle. In other portions of the line only demonstrations will be made and detachments of varying strength will be needed for many duties. We must, therefore, have recognized and convenient subdivisions of our normal formation.

German Formation in 1884.—The London *Times* of 24th September, 1884, gives the following description of the attack formation assumed by a German brigade of two regiments (six battalions) in the Grand Manœuvres of that year:

Two battalions were placed in the front line, and each extended three out of the four companies on a total front of 800 yards; these companies formed their own firing-lines and supports; the supports were 200 yards in rear of the firing-line; the fourth company followed 300 yards in rear of the supports, as a first reserve. The third battalion followed the two reserve companies at a distance of 500 yards. These three battalions belonged to one regiment, and the three battalions of the other regiment of the brigade followed much further in rear as a main reserve.

Here the supports could join their companies at about the third halt, the first reserve at about the sixth, the second reserve at about the thirteenth halt, while, if their original distance from the preceding line were 800 yards, the main reserve must march some 24 minutes, without halting, to join the firing-line, which would meanwhile advance some 1200 yards.

Length of Halts.—If the original distance of the firing-line from the position was 800 yards, and it was necessary to wait for the main reserve before assaulting, the halt at 300 yards would be about 14 minutes long.

If the assault were made when the third battalion joined the firing-line, this halt would be about three minutes. But could the assault be delivered then? The total force available would be only some two men to three yards. And we have just seen that the assault requires ten to fifteen men per yard.

If we consider the second regiment added to the firing-line, we will still have only three men per yard. This being insufficient, reserves would have to be called up from some further distance by another order. Would it not be better to dispose the troops in the first instance, where they will be at hand when needed?

Formation Suggested.—Plate II is an attempt to show the normal formation for serious attack of a division of infantry, three brigades, nine regiments, one regiment detached from the first brigade, and one from the second.

The firing-line is represented as composed of entire companies in line of groups. This formation is adopted in order to

secure unity of direction in the firing-line, in accordance with the views of Mayne, Maude, Home, Boguslawski, Hohenlohe, and others.

The general of division directs two brigades to attack, holding the third in reserve. The generals of the first and second brigades each direct one regiment to attack, holding the other in reserve. The colonels of the leading regiments each order two battalions to attack, holding the third as regimental reserve. The leading battalions each deploy one company as firing-line, the others following in successive lines as supports. The firing-line begins the movement, which is taken up by the troops in rear, so that, when the firing-line is at 1200 yards from the position, the formation is as represented.

As the advance continues, the first line halting to fire, the others close on it, the second joining at the moment when its aid is about to become necessary. The third, fourth, etc., continue this process of successive reinforcement until, the enemy being driven from his position, a fresh line takes up the pursuit or repels the counter attack.

Such is the only type of formation which can hope successfully to assault a well-defended position. It is, of course, understood that variations will constantly be made, to suit the terrain and the forces engaged. This formation, taken as a general guide, lends itself to such variations, and as such general guide it follows directly from the principles we have deduced of modern fire and its use in war.

If merely a demonstration be intended, the depth of the for-

mation may be reduced without confusion. If a temporary or local defense be contemplated, a still further reduction is easy.

If the accidents of the ground favor the attack more on one side than on another, the attack may be pushed home over the favorable ground, while the balance of the troops, still in this deep formation, advance more slowly, yet constantly ready to assault their portion of the position as soon as a first success is gained on either hand.

The formation, in successive lines, interdependent yet independent, is suitable for flank attacks, either general or local. And the number of lines and men per yard conform to the estimates of those who have assaulted positions under modern fire, both successfully and unsuccessfully.

CHAPTER 15.—PLUNGING FIRE—INDIRECT FIRE—NIGHT FIRE—RIFLE SIGHTS—RANGE-FINDERS—INTRENCHING TOOLS.

There are certain matters which, though not strictly within the scope of our subject, are yet sufficiently cognate to it to need brief mention here.

Indirect and Plunging Fire.

Plunging fire is that which is used against an object close behind a covering mass.

It has no value in the open field, but may be valuable in sieges, where the object is large and stationary, the ranges can be measured, and there is plenty of time.

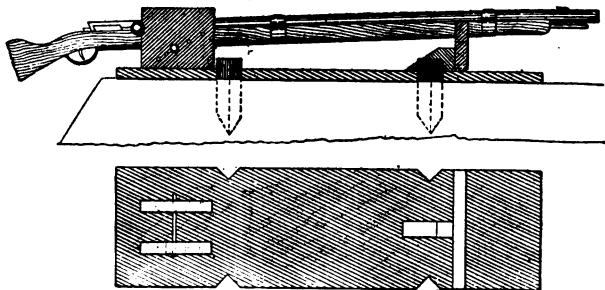
The firers must be placed at a suitable distance from the obstacle.

The efficacy of plunging fire depends on the angle of drop and height of the obstacle. If the latter be a parapet 8 feet high, the defiladed zone at 1000 yards will be 8x12, or 96 feet, and the protected zone for infantry 2.5x12, or 30 feet—the whole width of the terreplein. At 1300 yards the defiladed zone is 60 feet and the protected zone 19 feet. The range must therefore be more than 1000 yards; and the suitable range for any obstacle may be found in like manner.

A slight increase in elevation must be employed to cause the center of the nucleus to clear the interior crest of the obstacle.

The attack of fortified places and intrenched camps will, in future, witness an increase and development of the duties of infantry at the commencement of the siege. The supply of ammunition will be absolutely unlimited, the troops can fire with rests from behind cover, and the long range of the rifle will enable them to co-operate with the siege artillery, at least to the extent of harassing the garrison, and hindering the freedom of its movements and the vigor of its defense.

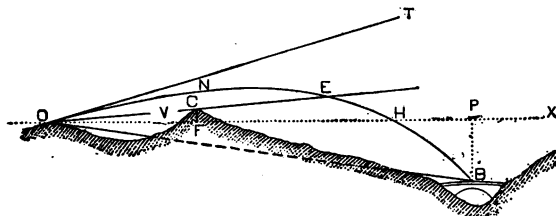
Rests may be constructed of boards, lying in which the rifles will be properly directed and the soldier can fire any number of rounds. A battalion of 400 men could easily fire 40,000 rounds in an hour.



Indirect Fire.

Indirect fire is that used against an object at a considerable distance behind a covering obstacle. While its use is almost confined to sieges, it may find occasional application in covering a debouche, bridge, or similar point, with fire from a distance, without exposing the firers.

It requires a knowledge of certain data—the range, distance and height of the obstacle, and height of the object and origin of fire.



1, 2. C higher and B lower than O.—Suppose C to be the obstacle, B the object, and O the origin of fire. If B were visible from O, it would be struck by fire aimed directly at it, with the proper angle of elevation, TOB . Draw the horizontal line OX , cutting C at V; B can then be struck by aiming at V, with the elevation TOH , provided the difference of height CF be less than the corresponding ordinate FN .

The point V in the horizontal is not easily determined. We

can strike B by aiming at the crest C, with the angle of elevation TOC . We must then determine the distance OE , at which the trajectory passing through B cuts OC prolonged, in order to determine the elevation to be used. If OE be less than OC , we must change the firing-point O .

Make $OB=D$, $OC=d$, $PB=b$, and $CF=c$.

From c and d we can obtain the angle EOX ; from b and D , the angle XOB .*

$$TOC = TOB - (EOX + XOB)$$

That is, the angle of elevation to be used is the angle of elevation for the range D , less the angle subtended by the object and auxilliary point C . For example:

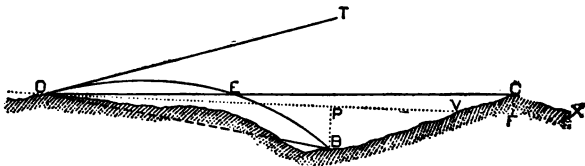
Suppose $D=1200$ yards; $TOB=3^\circ 42.5'$.

$d=400$ yards; angle of elevation, $52'$.

$c=20$ feet; EOX shows slope of 1 in 60, or 1° .

$b=90$ feet; XOB , slope 1 in 40, or $1^\circ 20'$.

$$TOC = 3^\circ 42.5' - 2^\circ 20' = 1^\circ 22.5'$$



*A slope of 1 in 60 corresponds nearly to an angle of 1° , and up to 15° the proportion is nearly constant, 1 in 4 corresponding to 15° .

But if $C=40$ feet, EOX becomes 2° , $TOC=3^\circ 42.5' - 3^\circ 20' = 22.5'$, which is less than the angle of elevation for D ; and under these conditions indirect firing is impracticable.

If C is beyond B , we have the same expression.

$$TOB = TOC + XOB + EOX, \text{ and } TOC = TOB - (EOX + XOB)$$

If $D=900$ yards, $TOB=2^\circ 28.5'$.

$d=1300$ yards, angle of elevation, $4^\circ 12'$.

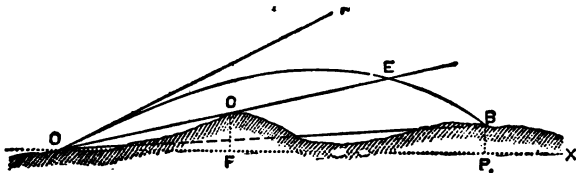
$b=45$ feet, XOB gives slope of 1 in 60, or 1° .

$c=65$ feet, EOX gives 1 in 60, or 1° .

$TOC=2^\circ 28.5' - 2^\circ = 28.5'$, and firing *may* be practicable—a question best settled by trial and observation.

But if $B=60$ feet, $XOB=1^\circ 30'$, and firing is impracticable.

3. Both Higher.—If B and C were both higher than O , EOB would be equal to $EOX - XOB$, and $TOC = TOB - EOB = TOB - (EOX - XOB)$.



If TOC is less than the angle of elevation for the range OC , or if the angle COB is greater than the angle TOB , indirect firing is not practicable under these conditions, and another auxiliary point must be found.

If $D=1000$ yards, $TOB=2^{\circ} 52'$.

$d=600$ yards, angle of elevation $=1^{\circ} 26.5'$.

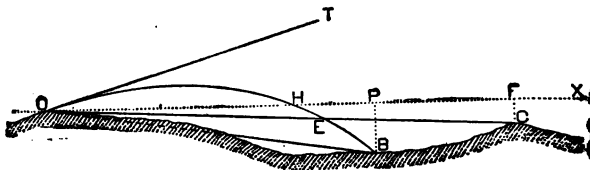
$b=50$ feet, XOB gives 1 in 60, or 1° .

$c=40$ feet, EOX gives 1 in 30, or 2° .

$TOC=2^{\circ} 52' - 1^{\circ} = 1^{\circ} 52'$.

But if $C=60$ feet, $EOX=3^{\circ}$, $TOC=2^{\circ} 52' - 2^{\circ} = 52'$, and firing is impracticable.

4. Both Lower.—If C and B are lower than O ,



$TOB=TOC + (XOB - XOC)$, and $TOC=TOB - (XOB - XOC)$.

If $D=900$ yards, $TOB=2^{\circ} 28.5'$.

$d=1300$ yards, angle of elevation $=4^{\circ} 12'$.

$b=90$ feet, XOB gives 1 in 30, or 2° .

$c=65$ feet, EOX gives 1 in 60, or 1° .

$TOC=2^{\circ} 28.5' - 1^{\circ} = 1^{\circ} 28.5'$, and firing *may* be practical.

But if $C=130$ feet, $EOX=2^{\circ}$, and C is not seen.

Or if $B=180$ feet, $EOX=4^{\circ}$, and firing is impracticable.

In computing the height of the origin of fire, the height which the rifle is held must be added.

Indirect fire must be corrected by observing its results;

when the elevation to be used has been determined, marks should be set up, at which the men aim.

Night Firing.

Experiments in night firing have given excellent results up to 600 yards. Beyond this distance the fire was found unreliable.

The lying position gave the best results. Whitening the sights was advantageous; this may be done by tying white rags over them.

With artificial lights, similar to bivouac fires, and the electric light, the results were good up to 600 yards, as also with the fire from prepared rests. With these the object, on which the rifles are laid during the day, may be any point over which the enemy must pass to attack.

The deadliness of modern fire has led many to think that night attacks will be frequently resorted to in future. In such attacks, close order would be used in order to maintain cohesion and control, and to insure the arrival of the force at the designated point.

The success of the attack depends on secrecy and rapidity; that of the defense on good outpost service, on such training as will bring every man to his post promptly and without confusion, and on the repulse of the enemy before he can close.

If an attack is to be feared, General Brialmont recommends that the defenders should keep up fires of brushwood during the night. He recommends placing them 2000 yards to the

front; but night firing is not reliable beyond 600 yards, and at 2000 yards the fires would be beyond the chain of sentries. They should be placed some 600 yards to the front, the sentries beyond them and hidden.

Rifle Sights.

Reasons have already been given why men should be taught to use a full fore-sight.

The rear sight should above all things be adapted to its purpose. No refinement which cannot be utilized in war, no matter how admirable it may be on the target range, adds to the value of a military rifle.

A battle between civilized forces, where the troops in defense expect a regular assault, is a different matter from an Indian fight, where there is no apprehension that such an assault will be delivered. In the latter the sights may be lowered to suit the range, free from the hurry and excitement which, in the former, must inevitably attend the near approach of the attack. Under the influence of this excitement, it must be recognized that a time comes, when "the men will have neither time nor disposition to fiddle with the sights." This indicates the necessity of a sight, giving a considerable range without ceasing to cover the ground.

For aiming at small objects at short range a lower sight is useful. This should be the sight without elevation—that is the fixed sight of the rifle.

For longer ranges, beyond the short zone, a leaf sight should be provided.

Taking these considerations together, the Germans use:

1. A fixed sight for about 300 yards.
2. A flap sight for about 390 yards.
3. A leaf sight for longer ranges.

The second is the true fighting sight.

The Buffington rear sight, with its complicated refinements, provides new opportunities for error on the part of the firer, obscures all the country round about, except that small portion visible through the opening, and thus increases the difficulty of catching the aim.

The scores made with it on the target range are no indication of its efficiency in battle, and for the practical use of war it is probably the worst rear sight now used on a military arm.

We need an open sight, simple, durable, and graduated for use with a full fore-sight.

The fixed sight should be for 200 yards. At that range the maximum error of the rifle is only .45 foot, so that aim may be taken directly at any object the size of a man's head, and, if aim be taken at the bottom of the object, an over-estimate of the distance will not suffice to cause a miss.

There should be a flap sight for 400 yards. This will cover all the ground, for standing men, from 0 to 400 yards.*

There should be a leaf sight for ranges between 400 and 1300

* See page 45.

yards, and another for ranges beyond 1300, the latter to be used in only the exceptional circumstances alluded to.

Range-Finders.

These instruments should be issued to troops and their use carefully taught.

There are many kinds, of which the following seem best adapted for the use of infantry.

1. The Labbez gives the range without calculation, and requires only one person to use it, though two are better.

A base of fixed length is used and the distance read directly from the instrument. Careful use of this instrument is said to give ranges within less than 2 per cent.

2. The Souchier, recently adopted by the Russians, gives the distance by multiplying a measured base by a factor engraved on the instrument. It is said to be nearly as accurate as the Labbez.

3. The Weldon, in which, by means of a prism, ground to certain angles, the extremities are determined of a base $\frac{1}{10}$ of the range. This has the great advantage of constant adjustment. An auxiliary prism gives the means of measuring a secondary base, if obstacles prevent the measuring of the first.

All these are of moderate cost, considered as an article of a company's equipment. Their use is easily learned, and they are easily carried in the pocket.

They should be issued to all companies of infantry.

Intrenching Tools.

The use of hasty intrenchments, by no likely to become more general in future. the rifle makes cover important, while the jectory makes even a slight intrenchment

The use of such works by the defense They are no longer intended as obstacles, ing a clear field of fire, but for cover from t The war of 1877-78 clearly proved their v gle to hold the "Green Hills" the Russian with bayonets, canteen-lids, and hands, dead into the gaps to bar the Turks."

The use of intrenchments by the assails in future. As ground is gained in the att against the efforts of the defender's support pose an obstinate fight between well-mat witness a line of trenches thrown up for ev

From his experience before Plevna, G pressed the opinion, that no earthwork except by intrenching at night the positio He complained of the lack of tools, and whe in the rapid advance to the south, he ga spades, which they carried on their backs.

In the beginning of this war the Russian to using the spade, but before it was ov

said: "If the government will not give the infantry portable spades, the soldiers will buy them with their last pence."

Infantry must be provided with intrenching tools; and these must not be carried in wagons, but by the men. Otherwise they will not be at hand when they are wanted, for the infantry will have to work on ground where wagons cannot pass. The spade must go with the rifle.

Various patterns of intrenching tools have been proposed. None has been adopted for our infantry, unless indeed the name be given to the broad knife which they carry.

In order to use the intrenching tool in the attack, the men should be trained to use it while lying down. Regarding this training we may quote from General Von Wechmar:

"Are we sufficiently exercised in the improvised works of fortification on the battle-field? We do not think so. Practice is absolutely necessary, in order to know how to rapidly choose the ground to be strengthened, and to calculate the number of men and tools, as well as the time required for the execution of the work."

APPENDIX.

FORT LEAVENWORTH, KAS., Dec. 5, 1891.

To the Secretary, U. S. Infantry and Cavalry School:

SIR—I have the honor to submit the following abstract of experiments conducted by me in infantry fire:

The ground on which the firing took place was an extensive sand-flat on the bank of the Missouri river, generally level, but marked by slight accidents of surface, sufficient to partially conceal the targets on occasion.

The ranges were unknown, but none were greater than 1000 or less than 500 yards.

The fire was uncontrolled, the men being allowed to use their own choice of elevation and object, except in the last experiment, when the ranges were given as guessed by the company commander, to whom they were unknown. In order to be sure that this was so, the targets were on this day placed at his own discretion by a sergeant detailed for that purpose.

A reasonable estimate of the distances would indicate that the average estimate of the firers was from thirty to fifty per cent. too great, which the very small percentage of hits would confirm.

The weather was favorable for good shooting, except on the fourth day (October 28th), when the wind was driving dust

across the range in sufficient quantities to obscure the targets; but not to an extent equal to that which would result from the smoke of a brisk musketry fire.

Two runs were made on each day, over the same ground, and in each run five halts were made, and four shots fired at each halt. For one of these runs the targets were placed at equal intervals of one yard between centers; for the other they were placed in groups of eight (nine in the flank groups), the total front being the same.

The object of the experiments was three-fold:

First—To find the percentages made by the best instructed men in uncontrolled fire when the ranges were really unknown.

Second—To compare these with those made when the fire was controlled, and the estimates of distance fairly correct.

Third—To compare, as far as possible, the vulnerability of lines of the same front, extended at equal intervals and in small groups.

The results are given in the table on page 251. It will be observed that the percentages are very small, running from 8.6, the largest, down to 1.27, the smallest.

The two runs of the same day gave the larger percentage on the groups in two cases, and on the extended order in three. In both the former instances the targets were grouped for the second run of that day, while in two of the latter the greater percentage was made on the first run. Both experiments against

	FIRST EXPERIM'T, OCT. 24.*		SECOND EXPERIM'T, OCT. 26.†		THIRD EXPERIM'T, OCT. 27.‡		FOURTH EXPERIM'T, OCT. 28.§		FIFTH EXPERIM'T, DEC. 2.¶	
	STANDING FIGURE.	KNEELING FIGURE.	KNEELING FIGURE.	KNEELING FIGURE.	KNEELING FIGURE.	KNEELING FIGURE.	LYING FIGURE.	LYING FIGURE.	LYING FIGURE.	LYING FIGURE.
	Extended at equal intervals.	In groups of eight.	Extended at equal intervals.	In groups of eight.	Extended at equal intervals.	In groups of eight.	Extended at equal intervals.	In groups of eight.	Extended at equal intervals.	In groups of eight.
Order of run.....	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.	1st.	2d.
Hits.....	50	83	29	12	23	53	14	13	35	28
Per cent.....	5.2	8.6	3.09	1.27	2.3	5.4	1.4	1.3	3.57	2.85
No. of men hit.....	26	32	20	8	16	32	11	12	25	16

* Company forty-eight strong, all sharpshooters or marksmen. Fire uncontrolled. Targets well shown.
† Company forty-seven strong, all sharpshooters or marksmen. Fire uncontrolled. Targets well shown.
‡ Company forty-nine strong, about fifty per cent. marksmen. Fire uncontrolled. Targets well shown.
§ Company fifty strong, all sharpshooters or marksmen. Fire uncontrolled. Targets obscured by dust blown across the range. Eight down on first run.
¶ Company forty-nine strong, thirteen marksmen, fifteen first-class men, twenty-one unclassified men, (of whom ten were recruits.) Elevations given as guessed by company commander. Targets partially concealed by ground from part of company at each halt.

the lying figures gave the larger percentage on the extended order.

The greatest contrast is found in the second experiment: Extended order, 3.09; groups, 1.27.

The groups showed the greatest number of men hit in three cases, and the extended order in two. It is to be remarked, however, that in one of the former cases the line of groups contained eight more targets than the extended line, and showed only one more man hit, while the number of hits was actually greater on the extended line, so that this case stands: Extended order, eleven men hit out of forty-two; groups, twelve men hit out of fifty.

The greatest contrast is found in the second experiment: Extended order, twenty men hit; groups, 8.

The influence of an erroneous estimate of distance is indicated by the contrast between the fourth and fifth experiments. In the former a company of the best instructed men made an average of 1.35 per cent., with twenty-three men hit. In the latter a company of thirteen marksmen, fifteen first-class men and twenty-one unclassified men made an average of 3.2 per cent., with forty-one men hit, simply by being compelled to use elevations reasonably well guessed.

These experiments are too few and incomplete to warrant any conclusive deduction, but they indicate:

First — That the results now obtained in our skirmish practice would not be obtained in war.

Second—That poor shots, using the right elevation, are more valuable than sharpshooters using the wrong one; and

Third—That between 1,000 and 600 yards a line of small groups is no more vulnerable than a line of the same front extended at equal intervals.

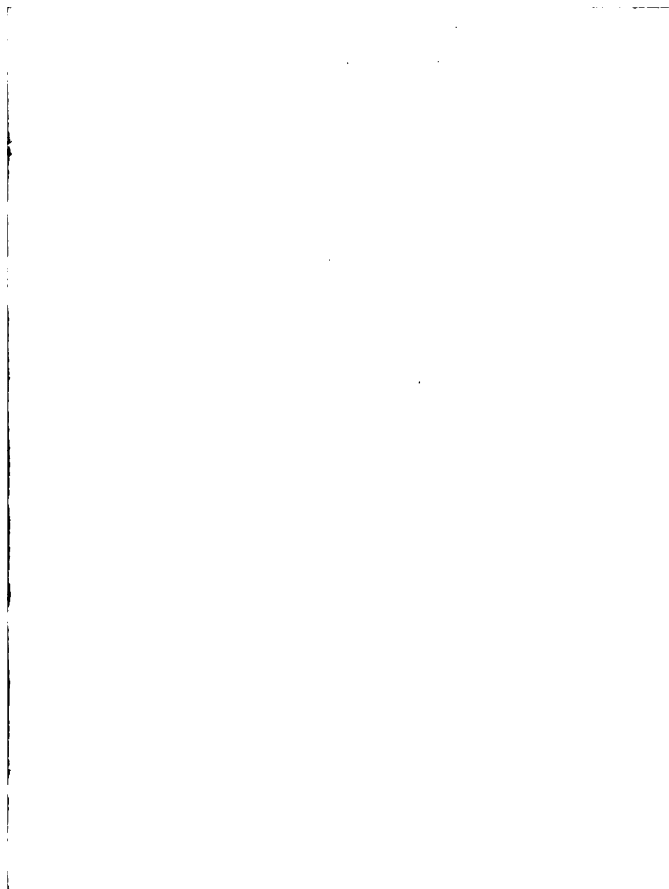
Though these are only indicated, they are highly important. If the results which we now obtain from our skirmish firing are misleading, the effort, at least, should be made to discover the reason why the best instructed men, on unaccustomed ground, with ranges really unknown, should make percentages so very much smaller than those made on the target range. If ignorance of the range can alone cause so great a reduction in the value of the fire, means should be discovered to lessen its effect, either by better instruction in estimating distances or by the use of more than one elevation. If it be true that between 1000 and 600 yards the vulnerability of infantry is not increased by retaining a formation in small groups, the fact should be ascertained by repeated experiment, clearly and beyond question. Many ideas on the employment of infantry have been based on the belief that individual dispersion becomes a necessary evil at considerable ranges. The disadvantages of such dispersion are acknowledged, and it has been considered inevitable only on account of the supposed excessive vulnerability of groups. If now these groups, admitting of control of movement and of fire, be found no more vulnerable than the extended line, they may be retained up to short ranges, at which, in battle, the junction of the various lines will have reduced the intervals to

such an extent that the formation will be practically a closed line, and the losses will depend chiefly on the relative discipline of the opposing troops.

I therefore respectfully suggest, in view of the importance of the subject, and the very considerable expenditure of care, time and material, which would be necessary for a complete and satisfactory solution, that this report be forwarded to the Adjutant General of the Army, in the hope that means may be found for more extended work in this direction. We especially need statistics of vulnerability from the number of men hit, in various positions and formations, which are almost entirely lacking now.

I must respectfully add that, in my opinion, this is not a question for theory, or for deduction from known-distance firing, but one which demands most careful experiment, under the conditions of war, as far as they can be reproduced in peace.

JOS. B. BATCHELOR, JR.,
First Lieutenant, Twenty-fourth Infantry.





_____ was obtained



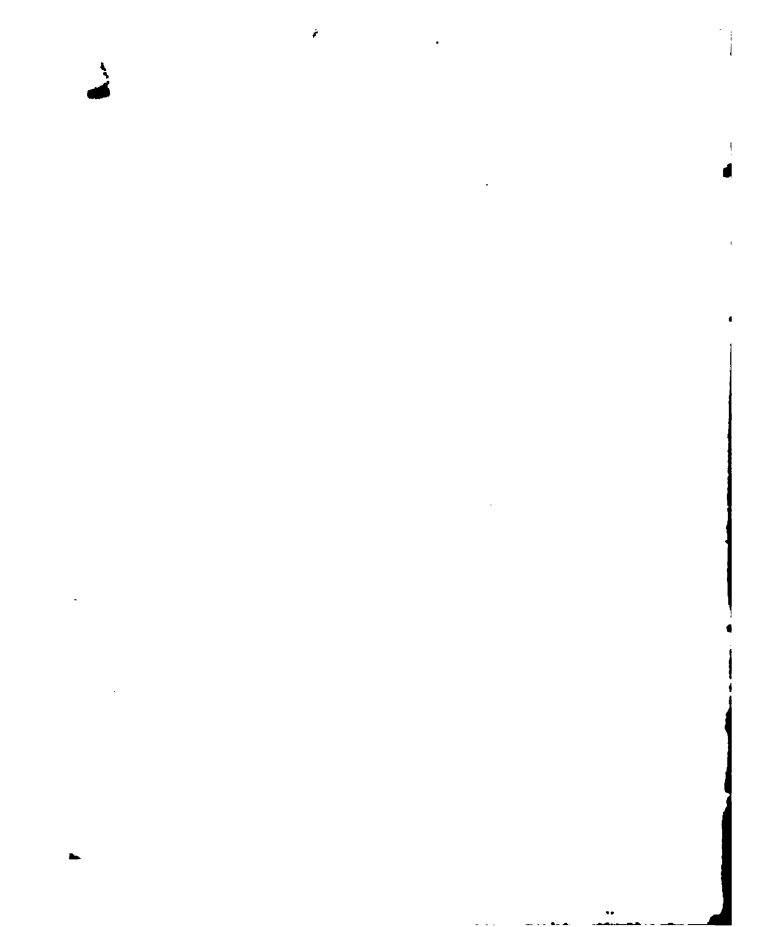




TABLE "B."—Series Obtained

Targets 20 me

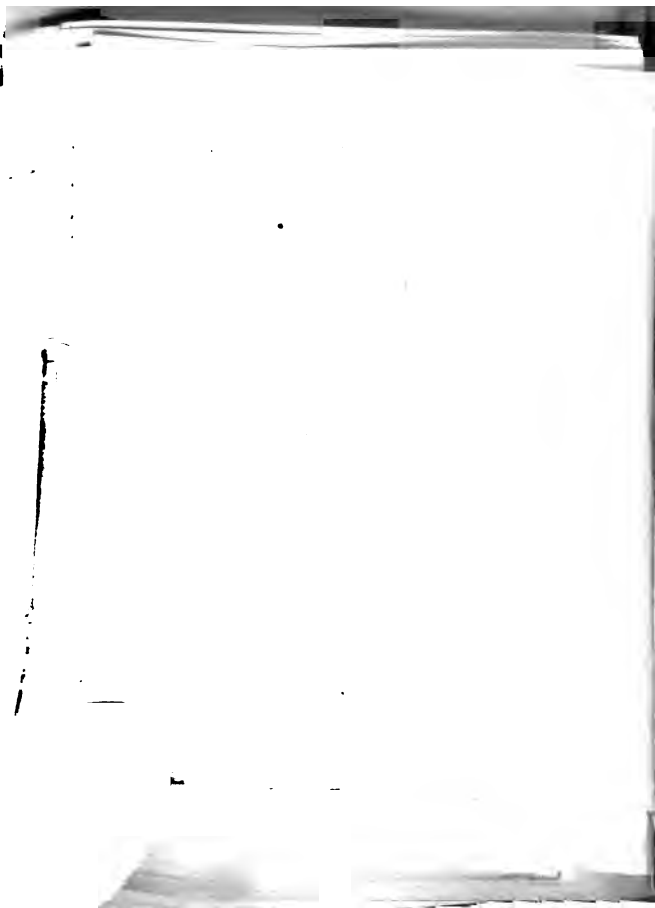


TABLE "B."

"B."

Targets 20 meters

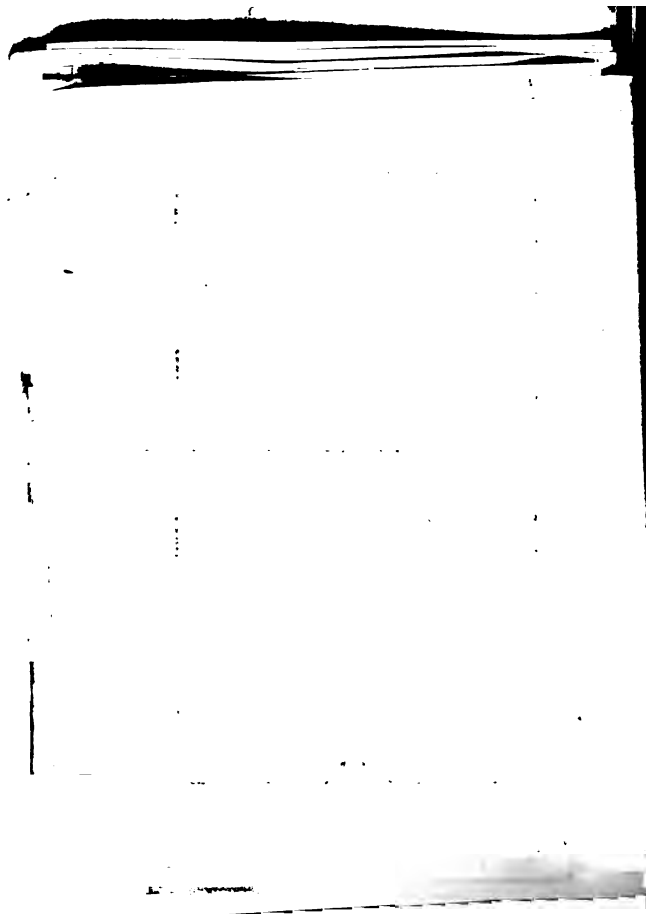
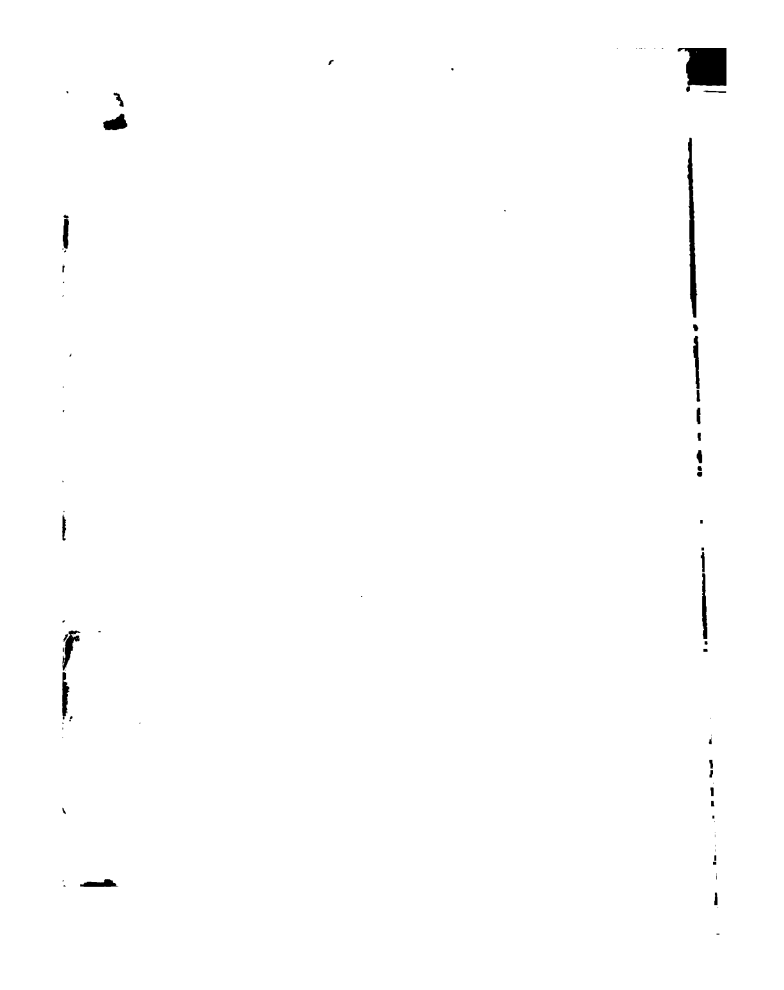


TABLE "B."—Series Obtained

Targets 20 me

OF NUCLEUS, DISTANCES IN METRES.							
110	100	90	80	70	60	50	40
4	6	11	17	28	39	24	34
7	16	29	40	44	55	56	51
1	.	.	.	1	2	5	5
1	.	.	2	3	5	10	20
2	2	2	7	11	17	23	26
4	9	14	22	32	43	41	45
...	...	3	4	4	13	12	17
...	...	7	16	22	31	37	40
...	1	2	1	2	4	2	4
3	3	4	5	7	9	12	22
...	1	.	1	.	2	2	2
...	1	1	2	4	6	8	12
...	...	...	1	2	4	2	4
...	...	...	5	7	6	7	21
...	...	1	2	.	2	1	.
...	3	4	5	5	8	10	16
...	...	3	1	3	1	3	5
...	...	5	6	5	4	12	20
...	...	1	2	3	3	2	8
...	1	3	5	12	8	6	12
...	...	...	1	1	2	3	5
...	...	...	2	7	9	10	20





910	920	930	940	950	960	970	980	990	1000
-----	-----	-----	-----	-----	-----	-----	-----	-----	------

...
...
...
...
6	3	6	7	3	1	...	...	...	...
36	32	32	34	26	10	8	6	2	2

1460	1470	1480	1490	1500	1510	1520	1530	1540	1550
------	------	------	------	------	------	------	------	------	------

[illegible]

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the following conditions are satisfied:

- (i) \mathcal{A} is a \mathcal{C}^1 -manifold
- (ii) \mathcal{A} is a \mathcal{C}^1 -submanifold of $\mathcal{C}^1(\mathbb{R}^n)$

then \mathcal{A} is a \mathcal{C}^1 -manifold.

Proof. Let \mathcal{A} be a \mathcal{C}^1 -manifold. Then \mathcal{A} is a \mathcal{C}^1 -submanifold of $\mathcal{C}^1(\mathbb{R}^n)$. Let \mathcal{A} be a \mathcal{C}^1 -submanifold of $\mathcal{C}^1(\mathbb{R}^n)$. Then \mathcal{A} is a \mathcal{C}^1 -manifold.

Proof. Let \mathcal{A} be a \mathcal{C}^1 -submanifold of $\mathcal{C}^1(\mathbb{R}^n)$. Then \mathcal{A} is a \mathcal{C}^1 -manifold.

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Proof. Let \mathcal{A} be a \mathcal{C}^1 -submanifold of $\mathcal{C}^1(\mathbb{R}^n)$. Then \mathcal{A} is a \mathcal{C}^1 -manifold.

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